PART I - WILDLIFE HABITAT MODELS

A. INTRODUCTION

As part of the NEPA process, USDI-Bureau of Land Management, Rock Springs District, Wyoming requested public response and comment on the Pinedale Anticline Oil and Gas Exploration and Development Project (Figure I.A-1), proposed within existing leases held by several companies including Alpine Gas Company, Amoco Production Company, McMurry Oil Company, Ultra Resources, Inc., Yates Petroleum Corporation, and others. The proposed Pinedale Anticline Project Area (PAPA) covers approximately 308 square miles (197,345 acres) of Sublette County in western Wyoming (Figure I.A-1).

Responses by the public (including agencies) during the comment period focused overwhelmingly on anticipated impacts to pronghorn, mule deer and sage grouse. Within the PAPA, pronghorns occupy approximately 149,800 acres of spring-summer-fall (SSF) range, 120 acres occupied only during winter (WIN), and 47,426 acres of crucial winter range (crucial WIN) (Figure I.A-2). Likewise, mule deer occupy 34,807 acres of SSF range, 14,465 acres of winter-yearlong (WYL) range, 27,220 acres of crucial WIN range and 26,131 acres of WIN range that BLM manages as crucial WIN range (Figure I.A-3). Numerous sage grouse leks, many of which are active, have been documented within and adjacent to the PAPA (Figure I.A-4). BLM's Pinedale Resource Area Resource Management Plan (RMP) defines the habitat where most sage grouse nest as areas within a 2-mile radius of leks (Figure I.A-4).

The RMP (BLM, 1987) emphasizes maintaining habitats to support wildlife populations at objectives established by Wyoming Game and Fish Department (WGFD). But, that only applies to big game species (pronghorn, mule deer, elk and moose) since there are no population objectives set for other game and nongame species. Since the approval of the RMP in 1987, the Wyoming Game and Fish Commission (1998) established a mitigation policy in which they recommend objectives for managing unavoidable adverse impacts to different categories of wildlife and wildlife habitats (Table I.A-1). Wildlife habitats are evaluated by their function (the arrangement of habitat features that sustain species, populations and wildlife diversity over time), and their value (the relative importance of habitat types and conditions in sustaining wildlife populations). However, the policy offers no guidance for measuring habitat function, habitat value, or impact effects that would result in a loss of function or value.

Summarized in Table I.A-1 are the Commission's five mitigation categories related to the relative importance of habitats to fish and wildlife species. These mitigation categories and associated mitigation objectives provide the basis for judging levels of impact significance. Relevant to pronghorn, mule deer and sage grouse are limited habitats that have been identified as "vital", and include big game crucial ranges. Habitats that are "vital" may be modified but no loss of habitat function is recommended since these habitats directly limit communities and populations and it may not be possible to restore or replace the habitat once impacted. Non-crucial winter-yearlong ranges and sage grouse nesting habitats are identified as those with "high" importance: if impacts occur WGFD would recommend replacement of affected habitats or enhancement of similar habitats to achieve no net loss of habitat function of the community impacted by a project.

The state of knowledge about impacts to fish and wildlife due to natural gas development is meager and has not substantially progressed during the past 20 years. While the list of impacts impacts identified by the public and agencies (most of them direct or primary) seems to grow with every project, NEPA practitioners base impact evaluations on assumption, conjecture and inference derived from studies of similar types of actions but in diverse locations and on different but similar species. Documented or implied impacts that are applicable to the various exploration/development scenarios and alternatives analyzed for the PAPA are summarized in Table I.A-2. These do not include effects of natural gas developments on species' populations; none have been studied or documented and hence the emphasis of impact analyses continues to be on wildlife habitat. However, there have been recent publications recognizing that there are generalized "zones of effect" surrounding human developments (Theobald *et al*, 1997) and roads (Forman and Alexander, 1998) that reduce wildlife use and densities in those areas.

The first part of this technical report documents procedures employed to develop and apply habitat models for analysis of impacts to pronghorn winter habitat, mule deer winter habitat and sage grouse nesting habitat on the PAPA. The modelling approach is similar to that applied to the Fontenelle Natural Gas Infill Drilling Projects (Reeve and Krawczak, 1995) but with some modifications. Results of modelling habitats and impacts have been summarized int the Pinedale Anticline Oil and Gas Exploration and Development Project draft environmental impact statement

(BLM, 1999a) but are discussed in more detail here.

The second part of this reports describes analyses of big game populations and sage grouse lek activities that might be affected by oil and gas developments over large geographic areas. The need for cumulative impact analyses of oil and gas developments in southwest Wyoming has long been discussed by the public and various agencies and has been recently addressed by BLM (1999b). Cumulative Impact Analysis Areas (CIAAs) analyzed for big game population trends includes pronghorn and mule deer populations inhabiting all or portions of Carbon, Fremont, Lincoln, Sublette, Sweetwater, Teton, and Uinta counties. The CIAA used to analyze possible impacts to sage grouse were the Sublette and Eden Upland and Small Game Management Areas that overlap all or portions of Lincoln, Fremont, Sublette and Sweetwater counties.

Cumulative impact is the incremental impact of an action or project that, considered individually, may be minor but when added to other past, present, and reasonably foreseeable future actions may be collectively significant (CEQ Guidelines, 40 CFR 1508.7). The issue of cumulative impacts has been recognized as having greater and greater importance nationally but the necessary analytic procedures have been slow to develop and there are no established methods for assessment, prediction or control (Williamson *et al.*, 1986). Cumulative impacts are usually thought of as expanding over a larger area and for a longer time span than impacts attributable to isolated actions (Horak and Vlachos, 1982) and so can be more easily characterized than they can be defined (Williamson *et al.*, 1986).

Until recent developments in computer-based Geographic Information Systems (GIS), the task of integrating and analyzing spatially distributed phenomena such as impact from multiple sources over large areas and for different time periods was unimaginable. The process is made much more complex if wildlife response to natural effects (eg. variations in habitat quality) is included with analysis of wildlife response to human effects, both of which need to be considered in cumulative analyses (Salwasser and Samson, 1985). The analyses presented here were conducted with GIS using a variety of information derived from ground-based field inventories, aerial photographs, satellite imagery, digital elevation data, WGFD data, BLM data, National Wetland Inventory (NWI) data, and data compiled from records maintained by Wyoming Oil and Gas Commission.

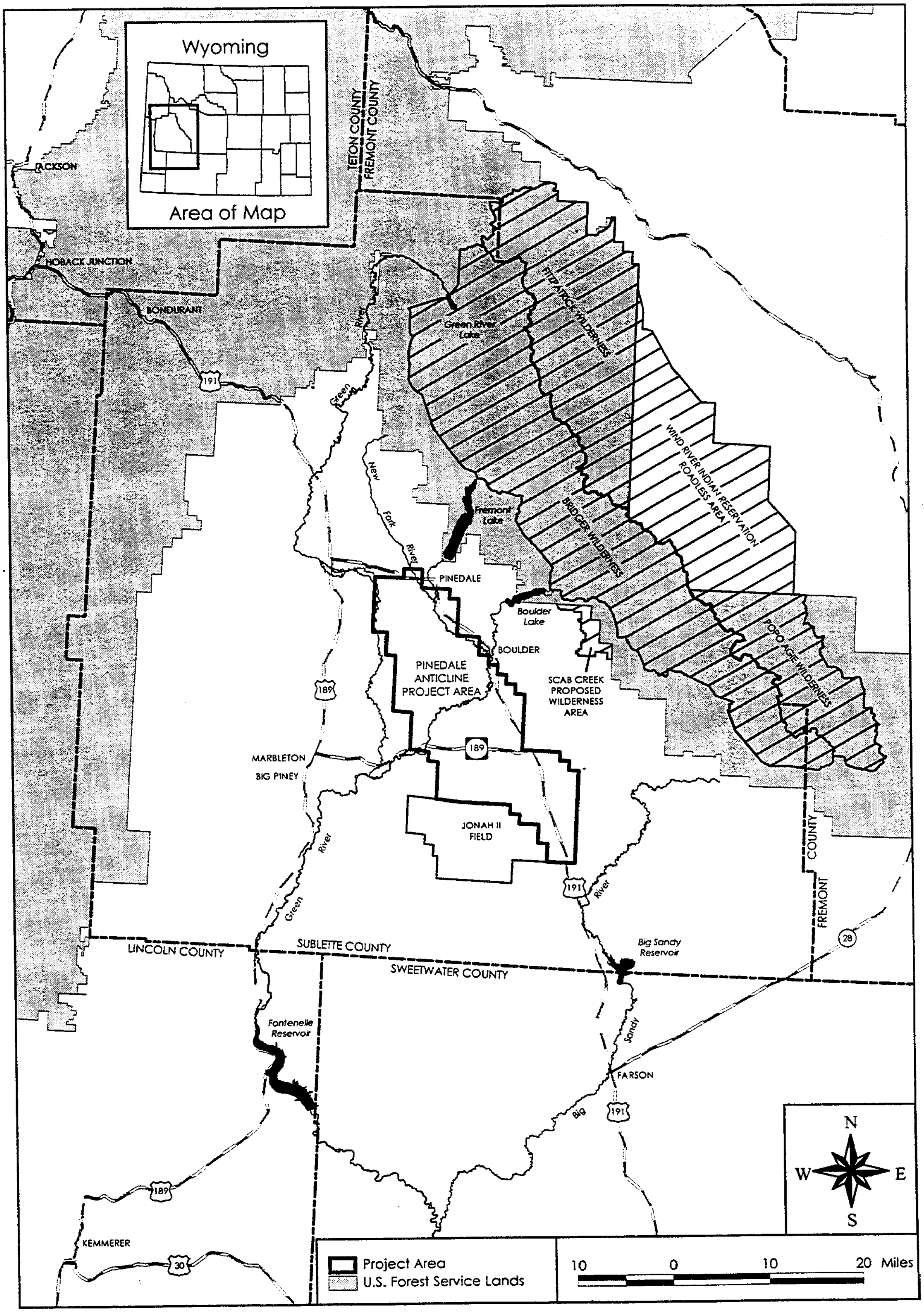

Figure I.A-1. General Location of the Pinedale Anticline Project Area.

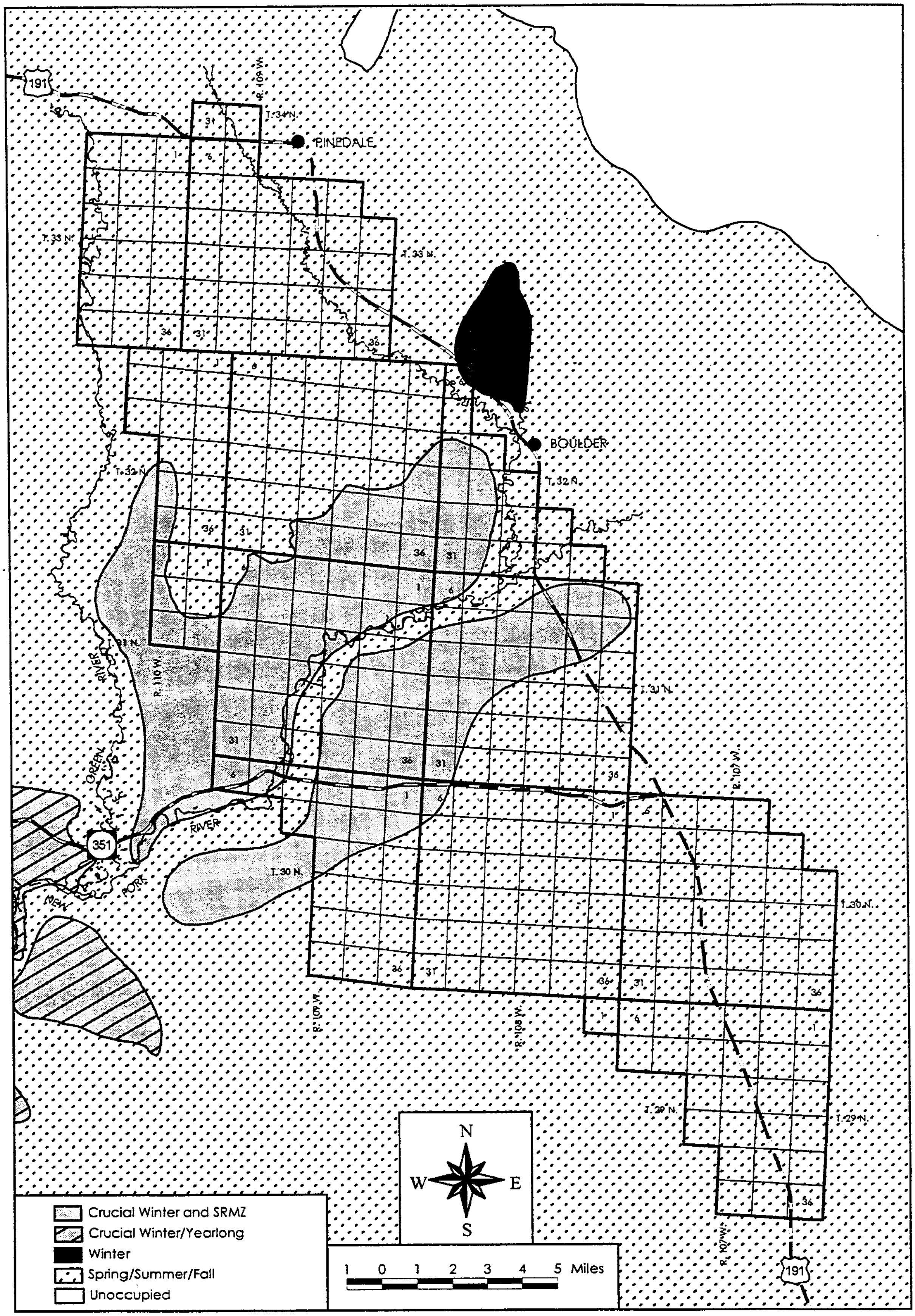

Figure I.A-2. Pronghorn Seasonal Ranges in the Project Area.

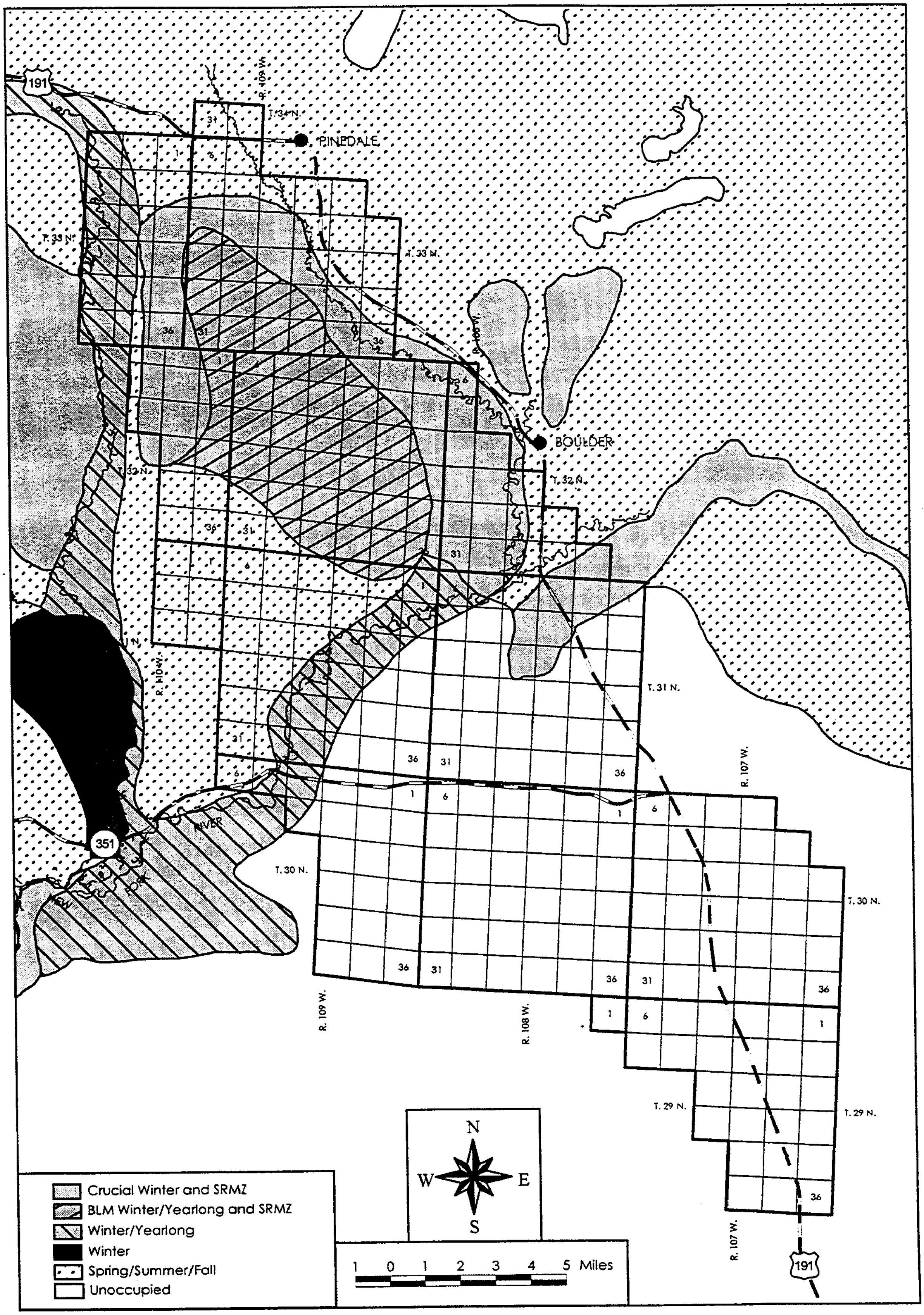

Figure I.A-3. Mule Deer Seasonal Ranges in the Project Area.

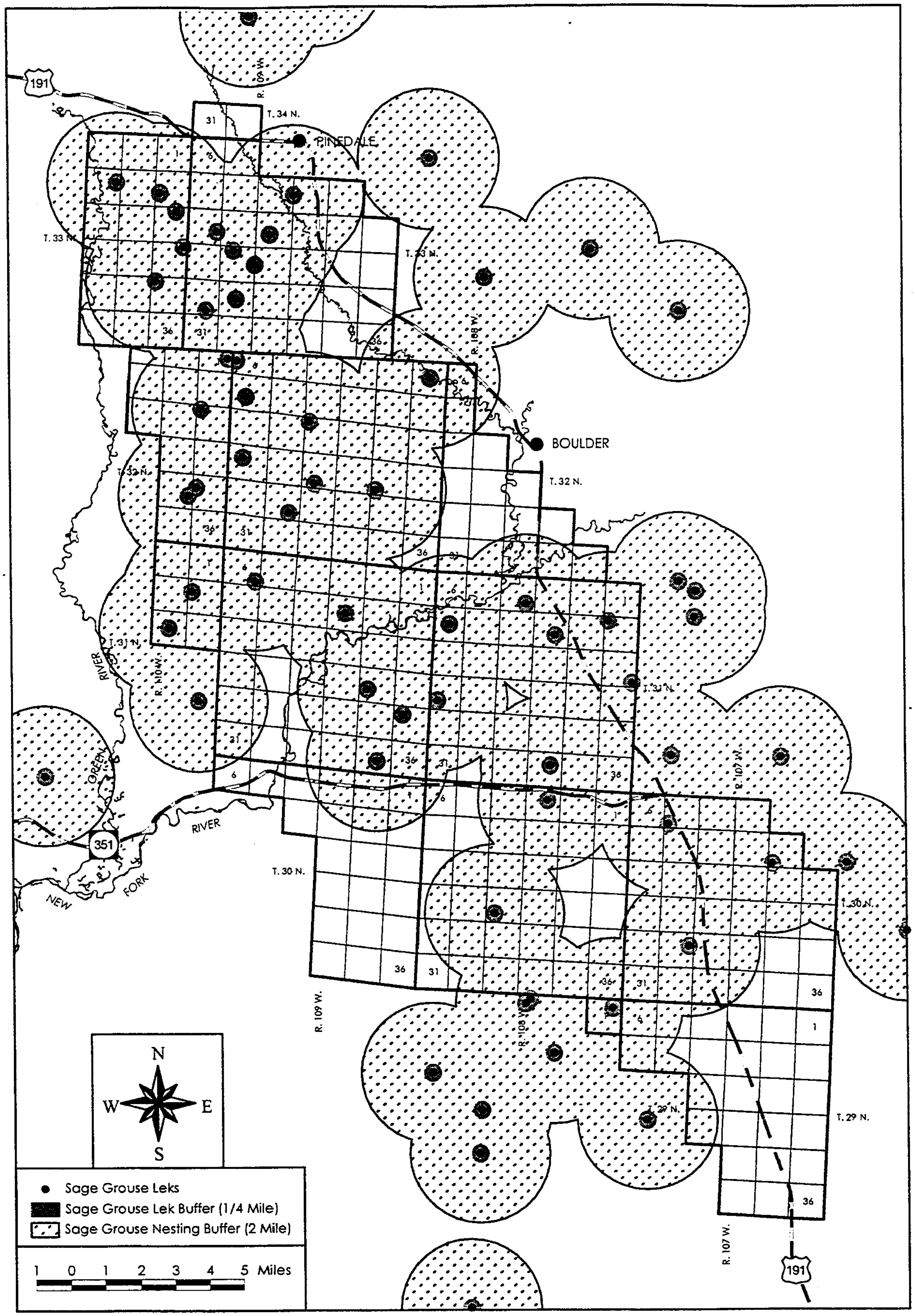

Figure I.A-4. Sage Grouse Leks in the Project Area.

Table I.A-1. Summary of Wyoming Game and Fish Commission Mitigation Policy as it applies to wildlife species and wildlife habitats.

Mitigation Category	Recommended Mitigation Objective	Applicable Species and/or Habitats
Irreplaceable Species/Habitats	No loss of habitat or habitat function: the impact is excluded	•Federally Listed Threatened and Endangered Species •Federally Delineated Critical Habitat
Vital Species/Habitats	No loss of habitat function (arrangement and capability of habitat components to sustain species, populations, and wildlife diversity over time); species supported by the habitat are unchanged.	•Federal Candidate Species •Wyoming Native Species of Special Concern Status 1 & 2 •Wyoming Crucial Habitats •Wetlands •Stream Class 1 (premium trout waters, fishery of national importance)
High Species/Habitats	No net loss of habitat function for biological community encompassing project area. The area will support species' populations by maintaining habitat function	•Wyoming Native Species of Special Concern Status 3 •Trophy Game Animal •Big Game, Trophy Game Winter-Yearlong Range •Parturition Areas •Riparian Habitats •Other Important or Limited Habitat (aspen, old growth, snags, cliffs, caves) •Stream Class 2 (very good trout waters, fishery of statewide importance) •Trophy Fisheries (managed for angling larger than average fish) •Species Fisheries (managed for angling unique fish species)
Moderate Species/Habitats	No net loss of habitat value (relative importance of habitat type and conditions to sustain socially or ecologically significant wildlife populations)	•Game Fish •Furbearing Animal •Wyoming Native Species Status 4 •Big Game Animal •Game Birds •Other Big Game and Trophy Game Seasonal Ranges •Stream Class 3 (important trout waters, fishery of regional importance) •Wild Fisheries (managed for angling non-stocked, natural reproducing fishery) •Basic Yield Fisheries (managed for angling opportunities, stocked or not)
Low Species/Habitats	Minimize reduction of habitat value (habitat is abundant or not essential to sustain community, population, or subpopulation).	•Native Species Status 5-7 •Small Game •Stream Class 4 (low production trout waters, no sustained fishing pressure) •Stream Class 5 (very low production waters, often without trout fishery) •Put-and-Take Fisheries (angling for hatchery-raised fish)

Table I.A-2. Summary of primary and secondary impacts to wildlife expected on the PAPA due to any of the exploration/development scenarios.

Impact Type	Species - Group - Habitat	Documented or Inferred Effects	Circumstances - Location	Sources
Primary Impacts				
wildlife-vehicle collisions	mule deer	mortality increases with traffic volume and winter severity; construction of new highways through deer travel lanes leads to substantial mortality	migration, winter range in SW Wyoming; NE Utah	Reeve, 1990; Romin & Bissonette, 1996
		summary of deer mortality on highways; collisions increase with traffic and vehicle speed	highways nation-wide; western US	Arnold, 1978; Reed, 1981; Reeve, 1986
	wildlife in habitats adjacent to roads	mortality of nocturnal, slow moving mammals, birds found in ROW vegetation, reptiles and amphibians in habitats adjacent to highways	highways nation-wide; Texas	Leedy, 1978; Case, 1978; Wilkins & Schmidly, 1980; Adams & Geis, 1984
wildlife mortality during construction	burrowing animals and wildlife using burrows	inferred from studies showing numerous vertebrate species use burrows made by burrowing mammals	prairie dog colonies, western US	Chase *et al*, 1982; Clark *et al*, 1982
	ground nesting birds, including sage grouse	inferred from vulnerability to trampling of birds nesting on beaches and crushed nests from ORV use in deserts	beaches on New Jersey coast; deserts in California	Burger, 1995; Luckenbach, 1978
mortality from toxic compounds	waterfowl, muskrats	inferred from increased metabolic rates due to increased thermal conductivity of oiled fur or feathers	laboratory studies	McEwan & Koelink, 1973; McEwan *et al*, 1974
	waterfowl eggs, adult waterfowl, domestic livestock	petroleum intoxication is fatal to waterfowl, cattle and presumably wild ruminants; petroleum coating waterfowl eggs is toxic to embryos	field and laboratory studies	Hartung & Hunt, 1966; Leepen, 1976; Edwards *et al*, 1979; Peterle, 1991
	wildlife (birds, mammals) mortality at open drilling pits	inferred from studies of wildlife mortality at petroleum pits to which they are attracted, become trapped, drown or die from oil toxicity	petroleum pits in Texas, Wyoming	Flickinger, 1981; Flickinger & Bunck, 1987; Esmoil & Anderson, 1995
	aquatic insects, fish	diesel fuels and lube oils are much more toxic to aquatic organisms than more volatile gasoline and jet fuel or heavier crude oil	nation wide and laboratory studies	Markarian *et al*, 1994
degradation of aquatic habitats	aquatic insects, fish, amphibians	inferred from studies showing accumulation of organic materials in water leads to decay, oxygen depletion; erosion increases sediments that reduce light penetration and photosynthesis by aquatic plants; sediments fill substrate interstices, detrimental to macroinvertebrates, spawning habitat and egg survival	aquatic habitats in western US	Burns, 1972; Megahan & Kidd, 1972; Ringler & Hall, 1975; Patton, 1973
fragmentation of habitats	breeding passerine birds	habitat occupancy by obligate shrub-steppe bird species declines with reduced shrub (sagebrush) cover and reduced shrub patch size	sagebrush steppe in western US, southern Idaho	Braun *et al*, 1976; Knick & Rotenberry, 1995
	small mammals	roads act as filters or barriers to animal movements by dividing habitats, especially wide roads with high speeds, high traffic volume	highways world-wide	Bennett, 1991

Table I.A-2. Summary of primary and secondary impacts to wildlife expected on the PAPA due to any of the exploration/development scenarios (continued).

Impact Type	Species - Group - Habitat	Documented or Inferred Effects	Circumstances - Location	Sources
impedance of migration	elk, deer, moose	berms and large diameter pipelines on ground or set on blocks are visual and physical barrier to movements	oil and gas developments in Alberta	Morgantini, 1985
	pronghorn	net-wire fencing associated with highways can prohibit pronghorns from reaching winter range and lead to significant winter mortality	Interstate 80, southcentral Wyoming	Riddle & Oakley, 1973
loss of forage	herbivores	once removed, shrub-dominated vegetation may take decades to revegetate ; shrub species do no readily regenerate from seed in topsoil	sagebrush steppe in intermountain west	Beauchamp *et al*, 1975; West, 1988
diminished use of habitats - interruption of life history functions	mule deer	areas within 0.125 mile of roads tend to be avoided; mule deer density was less (not significantly) within 0.6-mile radius of well drilling; mule deer mostly vacated a 0.5-mile area around well recompletion activities during winter; migratory mule deer avoid human disturbances more than resident deer	front range of Colorado; oil fields in central and western Wyoming; southern California	Rost & Baily, 1979; Easterly *et al*, 1991; Reeve, 1996; Nicholson *et al*, 1997
	pronghorn	effects of roads and well pads inferred from study showing pronghorn does with fawns escape from vehicles more than other groups; pronghorn density was lower within 0.6 mile of well drilling than beyond that distance	construction in southcentral Wyoming; oil field in central Wyoming	Reeve, 1984; Easterly *et al*, 1991
	moose	moose vacated open areas within 820 feet of vehicles and were unlikely to be within 0.6 mile of seismic activity; moose use roads plowed, free from snow but escape from trucks, snow mobiles, people on snowshoes or skis	oil field development in Alberta and western Wyoming	Horejsi, 1979; Rudd & Irwin, 1985
	sage grouse	inferred from observations and studies emphasizing importance of sound and auditory stimuli produced by males to attract females: noise pollution could diminish lek attendance and reproduction	coal mines in Montana, behavioral studies in intermountain west	Eng *et al*, 1979; Vehrencamp & Bradbury, 1989; Gibson, 1989, 1992, 1996
	nesting and wintering raptors	disturbance during nesting may cause nest abandonment, egg and/or chick mortality. Some species (red-tailed hawk, golden eagles, prairie falcons) more tolerant than others (ferruginous hawks, bald eagles). Wintering rough-legged are more sensitive to vehicles within 550 feet of perch than wintering golden eagles	studies of effects of various impact sources throughout western US	Fyfe & Olendorff, 1976; GYE Bald Eagle Working Team, 1983; White & Thurow, 1985; Grier & Fyfe, 1987; Andersen *et al*, 1990; Holthuijzen *et al*, 1990; Holmes *et al*, 1993
	breeding passerines	inferred from studies showing effects of well-traveled highways diminished breeding bird density; dust-shadow associated with dirt roads reduced densities of ground-nesting birds	highways in the Netherlands; oil pipeline studies in Alaska	Hanley *et al*, 1980; van der Zande *et al*, 1980
		Secondary Impacts		
increased recreational use	various wildlife species	extensive reviews indicate a wide variety of human recreational activities impact wildlife causing death, displacement, habitat modification, and pollution	summaries of studies done nation-wide	Knight & Gutzwiller, 1995
recreational ORV use	various wildlife species	off-road vehicles in desert ecosystems reduce numbers of breeding birds, small mammals and reptiles	deserts in southwest US	Carter, 1974; Luckenbach, 1978; Bury, 1980

Table I.A-2. Summary of primary and secondary impacts to wildlife expected on the PAPA due to any of the exploration/development scenarios (concluded).

Impact Type	Species - Group - Habitat	Documented or Inferred Effects	Circumstances - Location	Sources
encroachment in winter range by subdivisions	big game	development of residential areas, resorts, campgrounds, summer and winter homes degrade lower elevation big game winter ranges	big game winter ranges in intermountain west	Mower & Smith, 1989; Henderson & O'Herren, 1992
domestic dogs and cats	various wildlife species	domestic dogs and cats directly kill wildlife ranging from rodents to big game; wildlife alarm responses to dogs may be greater than native predators	nation-wide	Hamerstrom *et al*, 1968; George, 1974; Lowry & McArthur, 1978; Bangs *et al*, 1982
poaching	big game, furbearers	poaching big game and furbearers appears to increase concurrent with industrialization, influx of people	oil pipeline in Alaska; phosphate mines in SE Idaho	Klein, 1979; Kuck, 1986

B. BAYESIAN PROBABILITY MODELS

Use of Bayes' Theorem in wildlife habitat models has been described as a process that parallels the logical steps biologists use to evaluate habitat and formulate decisions under conditions of uncertainty (Williams *et al.*, 1977; Kling, 1980; Grubb, 1988; Aspinall and Veitch, 1993). The procedure is also at the core of pattern recognition (PATREC) models that usually include extending inferences about habitat to include predictions of animal densities (eg. Williams *et al.*, 1977; Kling, 1980; U.S. Fish and Wildlife Service, 1981; Grubb, 1988).

First, the investigator estimates the initial probability that some habitat condition(s) exists or will exist in the future. This initial probability is usually referred to as the prior probability and represents a "best guess" for the occurrence of a condition(s) until some additional information is known. The second step involves collecting sample data related to the condition(s) of interest. This step culminates in defining conditional probabilities that are expressions of inventory results. Conditional probabilities from the second step are finally used to revise the initial probabilities from step one to take the survey results into account. These final, revised probabilities are called posterior probabilities.

The wildlife habitat models developed and used here employ two broad categories of habitat conditions: habitat can either be **suitable** or **marginal**. Suitable habitat possess features or attributes that the wildlife species of concern utilizes or may depend on during some portion of the annual cycle. On the other hand, marginal habitat does not posses attributes that wildlife utilize or depend on to the same degree as suitable habitat and marginal habitat may even be avoided altogether. One would therefore expect to find that wildlife are present most often and at higher densities in the suitable habitat compared to marginal habitat although some individuals might occur in and utilize the marginal habitat at some time.

The models developed and applied on the PAPA are similar to those described by Reeve and Krawczak (1995) in the technical report prepared for the Fontenelle Natural Gas Infill Drilling Projects (BLM, 1995). The models are structured on probabilities which are integrated by Bayes' Theorem. A brief review of probability concepts and derivation of Bayes' Theorem is provided in Appendix A. Here, only the following terms will be generally defined:

S = Suitable Habitat (habitat in which animals would probably occur),

M = Marginal Habitat (habitat in which animals may or may not occur but with less certainty than in suitable habitat),

E = Environmental Condition (eg. some condition or level of vegetation cover type, distance from water, distance from road, etc.),

With these terms, the following is the mathematical expression of Bayes' Theorem with two categories of habitat, suitable and marginal:

$$P(S|E) = \frac{P(S)\,P(E|S)}{P(S)\,P(E|S) + P(M)\,P(E|M)} \quad \text{and} \quad P(M|E) = \frac{P(M)\,P(E|M)}{P(S)\,P(E|S) + P(M)\,P(E|M)} \quad \text{or} \quad P(M|E) = 1 - P(S|E)\,.$$

In these equations:

$P(S)$ = Prior Probability (P) of Suitable Habitat (S); a best estimate that the area is suitable habitat,

$P(M)$ = Prior Probability (P) of Marginal Habitat (M); a best estimate that the area is marginal habitat,

$P(E|S)$ = Conditional Probability (P) of the occurrence of the environmental condition (E) given that suitable habitat (S) is present,

$P(E|M)$ = Conditional Probability (P) of the occurrence of the environmental condition (E) given that marginal habitat (M) is present,

$P(S|E)$ = Posterior Probability (P) of the occurrence of suitable habitat (S) given the environmental condition (E); a revision of the prior probability of suitable habitat $P(S)$ based on the occurrence of the environmental condition (E) in the area.

$P(M|E)$ = Posterior Probability (P) of the occurrence of marginal habitat (M) given the environmental condition (E); a revision of the prior probability of marginal habitat $P(M)$ based on the occurrence of the environmental condition (E) in the area.

C. GIS ANALYSIS

Sources of data. Several sources were used to develop a vegetation map of the PAPA (including the adjacent Jonah Field II Project Area and a 2-mile zone surrounding the PAPA): field reconnaissance and mapping; BLM (1986) vegetation classification of Landsat imagery; Wyoming GAP Land Cover Map which is base on digital Landsat thematic mapper imagery; and 1994 black and white quad-centered NAPP aerial photographs enlarged to approximately 1:24,000 scale. The following vegetation types were distinguished: high and low density sagebrush steppe, mixed grass prairie, greasewood flats, desert shrub, riparian forest and riparian shrub, irrigated cropland, barren ground, other limited types (mountain shrub, limber pine, aspen), and human settlement.

Information on topography, slope, and aspect within the PAPA were derived from USGS 30-meter Digital Elevation Model (DEM) data. Wetlands and water sources were digitized from USFWS National Wetland Inventory superimposed on 1:24,000 USGS maps covering the PAPA. Road locations were combined from US Department of Commerce TIGER data and BLM road coverages. BLM also provided GIS coverages of well pad locations digitized from information on file with the Wyoming Oil and Gas Commission.

WGFD provided digitized big game seasonal range 1:100,000 scale maps in ARC/INFO coverage format for pronghorn and mule deer covering all herd units for each species in southwest Wyoming. Locations of sage grouse leks within and adjacent to the PAPA and within the sage grouse CIAA were obtained from WGFD and BLM biologists and agency records. Based on information contained in BLM resource management plans for Pinedale (BLM, 1987) and Green River (BLM, 1992) resource areas all areas within the PAPA except private lands were assumed to be grazed by cattle. For all areas within the PAPA, no distinctions were made for stocking rates, grazing practices or range conditions within any allotment.

Hardware and Software Used in Analysis. Hardware used included an IBM-compatible PC running Microsoft Windows NT 4.0 and ARC/INFO software.

Analytical Method. ARC/INFO vector coverages were used to assign suitable and marginal probability values (prior probabilities and conditional probabilities) to each geographic area within the Pinedale Anticline Project Area that was identified within each category for each habitat parameter of a habitat model. These coverages were then combined to create a master coverage. Required arithmetic operations were performed on the master coverage to compute posterior probabilities according to Bayes' Theorem.

Depending on posterior probabilities for suitable habitat, the polygons in the master coverage were grouped in the following categories for ranges of probability: zero, >0 to 0.50, >0.50 to 0.80, and >0.80 to 1.00 for a polygon to be suitable habitat. Results of each modeling procedure were summarized by acres of suitable habitat within the PAPA that were within each one of the four categories of probability for suitable habitat.

D. WILDLIFE MODELS

Species. Specific habitats utilized by three wildlife species were selected for habitat modeling and cumulative impact analysis within the PAPA: pronghorn winter range habitat, mule deer winter range habitat, and sage grouse nesting habitat. These 3 species were the focus of many concerns expressed by the public and agencies during the EIS scoping process.

Model Components. For each of the models described below, explicit reasons are provided for utilizing specific habitat conditions and accompanying conditional probabilities. There may be other habitat conditions that have not been included because data were not available for use in GIS analyses or the conditions could not be transformed for suitable analysis even though their inclusion might provide more realism. For example, the effect of fences on pronghorn habitat use is potentially an important model component not included because effects of a fence on a given parcel of land could not be spatially interpreted.

In all cases, however, probabilities have been subjectively assigned but are based on reasonable interpretations or estimates from information provided in scientific literature and wildlife research reports. The objective for each model was its application to cumulative impact evaluation. The effects of livestock grazing, human settlements, roads and well pads, and surface disturbances on each species were included as impact sources. However, the elimination of habitats by surface disturbances is the only indisputable impact to wildlife habitats; other effects of subdivisions, roads, well pads, and livestock on each species and associated habitats have not been clearly described in the literature in every case. However, recent literature has recognized "zones of effect" surrounding roads (Forman and Alexander, 1998) and other human developments (Theobald *et al*, 1997) within which wildlife densities are diminished.

Modeling Cumulative Impacts. The approach we used to assess cumulative impacts with the habitat models involved three steps. First, all effects due to known impact sources were removed by assuming appropriate conditional probabilities in each model that were related to absence of livestock grazing, absence of human settlements, roads and well pads, and no surface disturbances on any parcel within the PAPA. Output from this modeling effort was identified as the potential habitat conditions for any given parcel of land within the PAPA. That is, the models evaluate the landscape as though these conditions were not present and model output revealed how habitats within the landscape might appear without human-related uses.

The second step was to model habitats within the PAPA with all known or assumed existing conditions, including existing roads, well pads, human settlements and livestock grazing. Finally, each model was used to evaluate the cumulative effects of natural gas development within the PAPA but only as simulations within four areas of high interest for exploratory drilling on the Pinedale Anticline crest (Figure I.D-1). Simulations within those four areas were used because exact locations of well pads and roads anywhere within the PAPA cannot be determined for any of the project exploration/development scenarios or alternatives. Therefore, each wildlife habitat model was used to simulate the effects of three different well pad densities: 16 well pads/section (40-acre spacing); 8 pads/section (80-acre spacing); and 4-pads/section (160-acre spacing).

In addition, the use of one or two central production facilities (CPFs) in each section has been proposed as a means to reduce human presences once wells are operational. Briefly, all production equipment would be concentrated at one or two 5-acre pads in each section and gas from adjacent producing wells would flow to those. Except for occasional maintenance checks at producing well sites, routine visits would only occur at each CPF thereby reducing or eliminating "zones of effect" around producing wells. Too, those well pads could be reclaimed to 0.5 acre whereas standard producing wells would be reclaimed to 1.5 acre. In these simulations, only the modeled effects of well pads routinely visited by maintenance and operation personnel could be evaluated; no effects of well-field roads were included in simulations.

Each model employs a "zone of effect" (see for example Theobald *et al*, 1997) surrounding each well pad. For mule deer and pronghorn models those zones of effects are radii of 0.6 mile around each well pad; for sage grouse nesting habitat model the zone of effect is a radius of 0.15 mile (800 feet) around each pad. Models were not designed to differentiate effects of well pads that are closer than these radii. Zones of effect can overlap under some of the well pad spacing regimes but the models have no provisions to evaluate incremental impacts where zones overlap.

This three-step process is similar to the theoretical cumulative deterioration of habitat quality or quantity that was proposed by Horak and Vlachos (1982). However, the modeling output presented here does not identify any threshold point beyond which impacts are undesirable and cumulative impacts are significant (Horak and Vlachos, 1982). Clearly, these wildlife habitat models are a first step relating wildlife habitat attributes to environmental impacts and should be viewed as working hypotheses, not as definitive solutions to the problem of cumulative impact assessment. As such, they will undoubtedly require revision, refinement, and we hope will be improved in the future through critical and constructive review by other interested wildlife biologists and field validation, a desirable and necessary step in any modeling process (Morrison *et al.*, 1992; Conroy, 1993).

Indeed, data are being collected on the PAPA and vicinity that can be used to validate these models. Studies conducted by the University of Wyoming and funded in part by Ultra Resources, Inc. will provide information on pronghorn winter habitat use (Smith *et al.*, 1996), mule deer winter habitat use (Wyoming Cooperative Wildlife Research Unit, 1996), and sage grouse nesting habitat (Wyoming Cooperative Wildlife Research Unit, 1997).

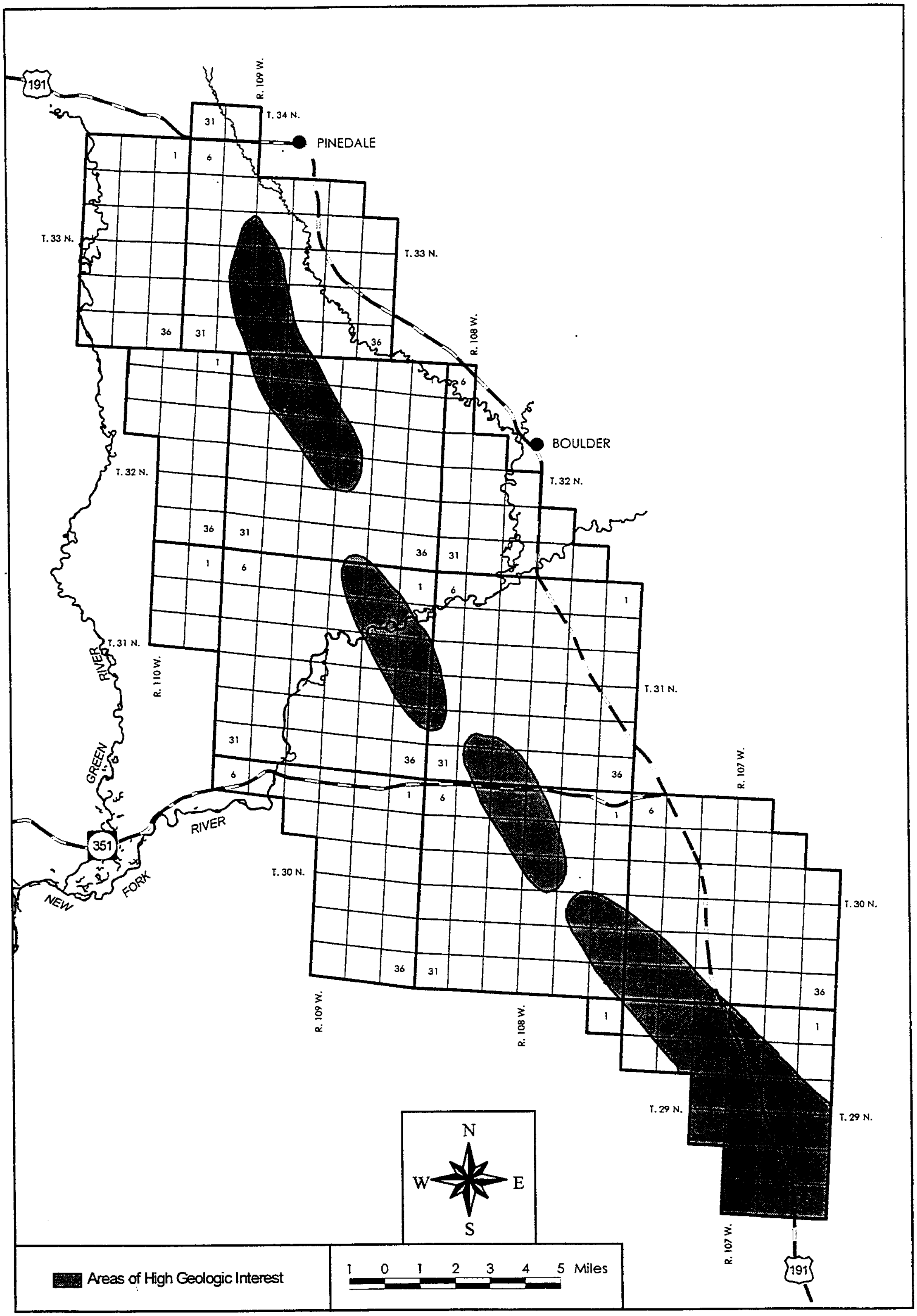

Figure I.D-1. Areas of High Geologic Interest Used to Simulate the Effects of Exploration/Development on the Pinedale Anticline Crest.

Pronghorn Winter Habitat Model. Table I.D-1 provides all component parts and their associated probabilities for the pronghorn winter habitat model. Assumptions and rationales for assigned prior probabilities and conditional probabilities for 8 habitat conditions are provided, below.

Prior Probabilities: We assumed that areas defined by WGFD as pronghorn crucial WYL ranges provided optimal habitats to wintering pronghorns. Crucial WYL ranges were assumed to be more suitable than marginal. Therefore, prior probabilities of $P(S) = 0.55$ and $P(M) = 0.40$ were assigned. We also assumed that non-crucial WYL ranges provided some level of suitable habitat but were less suitable than crucial WYL ranges (see Figure I.A-2 for pronghorn seasonal range locations in the PAPA). Within these areas, $P(S) = 0.45$ and $P(M) = 0.60$. All other seasonal habitats that are not used in winter (SSF ranges) and areas that were noted by WGFD as OUT were assumed to be unused by wintering pronghorn and prior probabilities for suitable and marginal habitat were set to zero ($P(S) = 0$ and $P(M) = 0$).

Vegetation Cover: The following vegetation types were mapped within the PAPA: low density sagebrush (less than 35 percent sagebrush cover), high density sagebrush (35 percent or more sagebrush cover), mixed grasslands, greasewood, desert shrub, riparian shrub and forest, irrigated cropland, barren ground, other limited types and human settlement. Studies conducted in Wyoming and adjacent states have emphasized the importance of sagebrush to wintering pronghorns (Martinka, 1967; Severson *et al.*, 1968; Bayless, 1969; Clary and Beale, 1983; Ryder, 1983; Alldredge and Deblinger, 1988; Easterly *et al.*, 1991). In particular, the amount of cover by sagebrush (Wyoming big sagebrush) has been directly linked to pronghorn density on numerous winter ranges (Irwin and Cook, 1985) and shrub height up to about 18 inches is an important winter range component (Ryder, 1983; Cook and Irwin, 1985). Taller sagebrush can be particularly important if it extends above crusted snow. We identified high density sagebrush as providing the most suitable winter conditions followed by low density sagebrush (Table I.D-1). Greasewood and saltbush vegetation are utilized under more extreme winter conditions, probably because they occur at lower elevations with less snow cover (Irwin *et al.*, 1984) and were assigned conditional probabilities that slightly emphasize suitability over marginal habitat conditions (Table I.D-1). All other vegetation types (mixed grasslands, riparian, cropland) were assumed to be more marginal than suitable ($P(E|S) = 0.10$, $P(E|M) = 0.40$ in Table I.D-1).

Topography: The importance of topographic relief to wintering pronghorns has been recognized by numerous investigators (Bruns, 1977; Allen and Armbruster, 1982; Clary and Beale, 1983; Ryder, 1983; Irwin *et al.*, 1984; Irwin and Cook, 1985; Guenzel, 1986). Slopes greater than 5% provide some protection from the wind (Guenzel, 1986) when thermal cover is necessary. Based on existing pronghorn winter habitat suitability models (Allen and Armbruster, 1982; Cook and Irwin, 1985), we assigned conditional probabilities to the four slope classes shown in Table I.D-1.

Slope Aspect: Studies of wintering pronghorns in southern Wyoming have recognized the importance of topographic slopes in providing shelter from prevailing winds (Ryder, 1983; Guenzel, 1986). Strong winter winds in southwestern Wyoming are mostly from the west and southwest (Martner, 1986). Under similar conditions in southcentral Wyoming, Ryder (1983) found wintering pronghorns to select northeast-facing slopes in a normal winter but they selected northwest slopes during a mild winter. Likewise, the availability of northwest-facing slopes on numerous pronghorn winter ranges in Wyoming and surrounding states appeared to influence pronghorn densities (Irwin and Cook, 1985). Where winter wind is not so prevalent, pronghorns are likely to select warm slopes that face west, southwest, and south (Clary and Beale, 1983). The conditional probabilities noted in Table I.D-1 reflect this information.

Elevation: In western Wyoming, pronghorns migrate to lower elevation winter ranges that are more often free of snow than higher elevations (BLM, 1987; BLM, 1992). We assumed that elevations within the PAPA that were less than mid-point elevation available (half way between the highest and lowest elevation in the portion of the Sublette Herd Unit overlapping the Pinedale Resource Area) were more suitable than marginal ($P(E|S) = 0.60$ and $P(E|M) = 0.40$) and elevations higher than the mid-point were more marginal than suitable ($P(E|S) = 0.40$ and $P(E|M) = 0.60$). These conditions would be expected to vary from year to year depending on snow depth and cover at higher elevations.

Overlap With Elk or Mule Deer Winter Ranges: Several authors have suggested that competition for forage may exist between pronghorns and mule deer (Mackie, 1981) but probably less between pronghorns and elk (Lyon and Ward, 1982). Elk that inhabit Wyoming's Red Desert have the greatest dietary overlap with pronghorns (10 percent) during summer and fall (Olsen and Hansen, 1977). In western Wyoming, elk and mule deer utilize sagebrush-grasslands extensively on low elevation winter ranges (Oedekoven and Lindzey, 1987) but on the PAPA, these species' winter ranges do not extensively overlap crucial and non-crucial winter-yearlong pronghorn ranges. We assumed that winter grazing, primarily by mule deer, could reduce the amount of forage available to wintering pronghorns. Therefore, areas where no winter range overlap is likely were identified as more suitable than areas of range overlap. Conditional probabilities for suitable and marginal conditions are provided in Table I.D-1.

Grazing By Livestock: Pronghorn diets on short-grass prairies overlap more with those of sheep than with cattle although grazing pressure by cattle is greatest in lowland plant communities (Schwartz and Ellis, 1981). Taylor (1975) estimated overall competition between cattle and pronghorns in the Red Desert during winter was 19.7 percent but was 47.2 percent between wintering domestic sheep and pronghorns. In another study in the Red Desert, dietary overlap between cattle and pronghorns appeared greatest during fall (20 percent) but lowest in winter (Olsen and Hansen, 1977). Nevertheless, wintering cattle in the Red Desert were observed to mostly occur in sagebrush-grass and rabbitbrush vegetation (Miller, 1983) and the potential for competition with pronghorns and/or displacement of pronghorns from specific vegetation patches by cattle exists. Diets of domestic sheep overlap pronghorn diets much more than other livestock (Taylor, 1975; Olsen and Hansen, 1977; Severson *et al.*, 1980). Earlier studies also indicate competition between pronghorns and domestic sheep (Buechner, 1950; Hoover *et al.*, 1959). In Utah, moderate grazing by sheep during winter made those areas unfavorable for pronghorn winter use until new spring vegetative growth occurred (Clary and Beale, 1983). We therefore assumed that pronghorn winter ranges without any livestock grazing would be more suitable than ranges with grazing, but all pronghorn ranges in the PAPA, including some private lands, are subject to grazing. Conditional probabilities for suitable and marginal conditions are provided in Table I.D-1. The actual impact of livestock grazing on pronghorns would depend on a variety of factors including precipitation, stocking rates of livestock, duration of grazing, season of grazing and grazing system (Autenrieth, 1978; Yoakum, 1980; Severson and Urness, 1994).

Distance to Nearest Road or Well Pad: There are few studies documenting pronghorn response to roads, vehicles, and/or oil and gas industry activities during winter but there has been recent emphasis placed on "zones of effect" surrounding human developments (Theobald *et al*, 1997) and roads (Forman and Alexander, 1998) that influence animal densities proximate to these.

In central Wyoming, the density of wintering pronghorns was significantly lower within 0.6 mile of an oil well being drilled than either before or after drilling and densities were lower within 0.6 mile than beyond that distance while drilling occurred (Easterly *et al.*, 1991). Data from that study indicate that wintering pronghorns tended to feed and bed farther from active wells in oil fields than suggested by random locations (Easterly *et al.*, 1991). Pronghorns tend to occur in large groups during winter that are more responsive to vehicles than small groups or individual animals and densities after the rut (early winter) in central Wyoming appeared to be directly related to distance from roads where traffic levels are characteristically low (Yeo *et al.*, 1984). All areas within the PAPA that were 0.6 mile or less from roads or well pads were assumed to more marginal than suitable ($P(E|S) = 0.40$, $P(E|M) = 0.60$) and areas greater than 0.6 mile from a road or well pad were identified as more suitable than marginal ($P(E|S) = 0.60$, $P(E|M) = 0.40$).

Surface Disturbance: Any surface disturbance, whether by road or well pad construction, would remove vegetation and so make that site unusable by pronghorns. Consequently, levels of any other habitat condition would be totally negated and so conditional probabilities for both suitable and marginal habitat were set to zero. If no surface disturbance was present, conditional probabilities for suitable and marginal habitat were each set to 0.50 so that the effect of no surface disturbance would not counter effects of other habitat conditions.

Maximum areas of surface disturbance that would apply to construction-related disturbances were used to evaluate existing and proposed features within the PAPA: well pads, roads, pipeline corridors, joint road and pipeline corridors. Producing well pads were assumed to cover 3.7 acres; collector roads, 3.9 acres/mile; local resource roads with adjacent buried gathering pipelines, 8.5 acres/mile; resource roads, 4.8 acres/mile.

Mule Deer Winter Habitat Model. Table I.D-2 provides all component parts and their associated probabilities for the mule deer winter range habitat model. Prior probabilities and conditional probabilities for 8 habitat conditions are defined, below.

Prior Probabilities: We assumed that areas defined by WGFD as mule deer crucial WYL and crucial WIN ranges provided optimal habitats to wintering mule deer that were much more suitable than marginal. For these ranges,

Table I.D-1. Model for Pronghorn Winter Habitat.

Prior Probabilities:	Suitable	Marginal
Crucial WYL and Crucial WIN Range	0.55	0.40
Non-Crucial WYL and Non-Crucial WIN Range	0.45	0.60
Other Seasonal Ranges	0.00	0.00

Conditional Probabilities:	Suitable	Marginal
1. Vegetation cover:		
a. High Density Sagebrush	0.35	0.20
b. Low Density Sagebrush	0.30	0.20
c. Greasewood-Saltbush	0.25	0.20
d. Other (Riparian, Cropland-Pasture)	0.10	0.40
2. Topography:		
a. Slopes ≥ 10% but ≤ 25%	0.45	0.25
b. Slopes ≥ 5% but < 10%	0.35	0.25
c. Slopes < 5% or > 25% but < 100%	0.20	0.50
d. Slopes > 100%	0.00	0.00
3. Slope Aspect:		
a. Northwest and Northeast Aspects (> 290° and < 80°)	0.40	0.25
b. Other Aspects (≤ 290° and ≥ 80°)	0.35	0.30
c. Flat (No Aspect)	0.25	0.45
4. Elevation:		
a. < 0.5 x (Maximum Elevation + Minimum Elevation)	0.60	0.40
b. > 0.5 x (Maximum Elevation + Minimum Elevation)	0.40	0.60
5. Overlaps With Elk and Mule Deer Winter Range:		
a. No	0.60	0.40
b. Yes	0.40	0.60
6. Grazing By Livestock (all classes):		
a. No grazing	0.60	0.40
b. Grazing	0.40	0.60
7. Distance to Nearest Road (Not 2-tracks), Well Pad, or Human Settlement:		
a. > 0.60 mile from road/well pad/house	0.60	0.40
b. ≤ 0.60 mile from road/well pad/house	0.40	0.60
8. Surface Disturbance:		
a. No	0.50	0.50
b. Yes	0.00	0.00

therefore, $P(S) = 0.60$ and $P(M) = 0.30$ were assigned. Non-crucial WYL and WIN ranges were assumed to have some levels of suitability but were less suitable than marginal (see Figure I.A-3 for mule deer seasonal ranges in the PAPA). For non-crucial winter ranges $P(S) = 0.40$ and $P(M) = 0.70$. We also assumed that ranges used only in summer (SSF range) and areas that were noted by WGFD as OUT would not be used during winter. In those areas, $P(S) = 0$ and $P(M) = 0$.

Vegetation Cover: Mule deer wintering areas are on lower elevations in western Wyoming and southeastern Idaho where deer are almost always seen in sagebrush-grasslands (Kvale and Kuck, 1984; Oedekoven and Lindzey, 1987) although mixed mountain shrub communities and juniper, if available, are frequently used (Kvale and Kuck, 1984; Cundy, 1989; Reeve and Lindzey, 1991). In the portions of the Sublette Mule Deer Herd Unit, wintering mule deer may utilize riparian communities and willows may be consumed with some frequency (Cundy, 1989). Since wintering mule deer are frequently observed in drainages (Oedekoven and Lindzey, 1987), riparian zones associated with these were judged to be potentially suitable habitat. Vegetation dominated by tall shrubs are infrequently utilized (Kvale and Kuck, 1984). Saltbush vegetation may be utilized by mule deer during winter but apparently not greasewood (Cundy, 1989). The following vegetation types were mapped within the PAPA: low density sagebrush, high density sagebrush, mixed grasslands, greasewood, desert shrub, riparian shrub and forest, irrigated cropland, barren ground, other limited types and human settlement. Of these, low density sagebrush was assumed to be most suitable for wintering mule deer ($P(E|S) = 0.40$ and $P(E|M) = 0.20$). Riparian vegetation, high density sagebrush, cropland and greasewood-saltbush were assumed to be more marginal than suitable (Table I.D-2).

Topography: Wintering deer tend to select drainages, flat and gentle slopes, and ridges over other topographic features (Oedekoven and Lindzey, 1987; Reeve and Lindzey, 1991). Steep slopes are used by some deer but with diminished frequency (Kvale and Kuck, 1984; Oedekoven and Lindzey, 1987; Reeve and Lindzey, 1991). Topographic variation appears to be a consistent component of mule deer winter ranges since deer are usually observed on slopes (Kvale and Kuck, 1984; Oedekoven and Lindzey, 1987; Reeve and Lindzey, 1991; Easterly *et al.*, 1991). The range of slopes in each topographic class used in the model (Table I.D-2) was assigned subjectively but could be easily modified with field data. Conditional probabilities for suitable and marginal conditions are provided in Table I.D-2.

Slope Aspect: Results from studies of wintering mule deer in and near Wyoming clearly point to the importance of south and west aspects to deer (Kvale and Kuck, 1984; Oedekoven and Lindzey, 1987; Reeve and Lindzey, 1991). We assumed that probabilities of flat areas with no aspect were as suitable as marginal ($P(E|S) = 0.50$ and $P(E|M) = 0.50$). Conditional probabilities for suitable and marginal conditions associated with slope aspect are provided in Table I.D-2 and emphasize the suitability of south and west aspects.

Elevation: Mule deer typically migrate to lower elevations within winter ranges (Kvale and Kuck, 1984; Reeve and Lindzey, 1991). We assumed that elevations within the PAPA that were less than mid-point elevation available (half way between the highest and lowest elevation in the Sublette Herd Unit that coincides with the Pinedale Resource Area) were more suitable than marginal ($P(E|S) = 0.60$ and $P(E|M) = 0.40$) and elevations higher than the mid-point were more marginal than suitable ($P(E|S) = 0.40$ and $P(E|M) = 0.60$). These conditions would be expected to vary from year to year depending on snow depth and cover at higher elevations.

Overlap With Elk or Pronghorn Winter Ranges: Competition between wintering mule deer and elk for forage has been recognized and elk may be more competitive than mule deer for forage (Mackie, 1970, 1981). Competition for winter browse between mule deer and pronghorns could occur where their winter ranges overlap (Mackie, 1981), particularly since both species consume saltbush and winterfat although not necessarily during the same season (Cundy, 1989). We assumed mule deer winter ranges that overlapped winter ranges of elk or pronghorns were probably less suitable ($P(E|S) = 0.40$ and $P(E|M) = 0.60$) than mule deer winter ranges with no overlap ($P(E|S) = 0.60$ and $P(E|M) = 0.40$).

Livestock Grazing: Effects of livestock grazing on wintering mule deer may be mixed. On one hand, livestock grazing has been viewed as beneficial to mule deer since livestock remove perennial herbaceous vegetation while allowing the shrubs that are utilized by deer to thrive (Severson and Urness, 1994). On the other hand, studies reviewed by Mackie (1981) indicate that livestock may preclude deer use or at least interfere with their utilization of available habitats. During summer, diets of cattle may overlap substantially, up to 38 percent, with mule deer diets mostly through similar consumption of bunchgrasses (Hansen and Reid, 1975). However, summering cattle also browse on true mountainmahogany (Hansen and Reid, 1975) and on saltbush and winterfat in the region (Cundy, 1989). We therefore assumed that mule deer winter ranges without any livestock grazing would be more suitable than ranges with livestock grazing. Conditional probabilities for suitable and marginal conditions are provided in Table I.D-2. The actual impact of livestock grazing on mule deer depend on a variety of factors including precipitation, stocking rates of livestock, duration of grazing, season of grazing and grazing system (Mackie, 1981; Severson and Urness, 1994).

Distance to Nearest Road or Well Pad: Results of a study conducted in Colorado suggested that areas within 0.125 mile of roads (660 feet) tended to be avoided by mule deer (Rost and Baily, 1979) but mule deer also appear to habituate to high traffic volumes that occur on interstate highways (Ward *et al.*, 1980). In central Wyoming, mule deer wintering in the vicinity of an oil field were found to not be significantly affected by oil field activities and well drilling (Easterly *et al.*, 1991). However, data from that study indicate that mule deer density was less within a 0.6-mile radius from well drilling activity than beyond 0.6 mile. And, mule deer bedding and feeding sites were significantly farther from active oil wells than random sites within oil fields although there were no similar significant differences found between distances from roads to bedding and feeding sites compared to random sites in oil fields (Easterly *et al.*, 1991). Nevertheless, we assumed that areas 0.6 mile or less from roads or well pads were not as suitable habitat for wintering deer as areas beyond 0.6 mile. The assumption does not rule out mule deer use of areas near roads or well pads, but only indicates areas farther away probably provide more suitable habitat.

Surface Disturbance: Any surface disturbance would remove vegetation and so make that site unusable by wintering mule deer. Consequently, levels of any other habitat condition would be totally negated and so conditional probabilities for both suitable and marginal habitat were set to zero. If no surface disturbance was present, conditional probabilities for suitable and marginal habitat were each set to 0.50 so that the effect of no surface disturbance would not counter effects of other habitat conditions. Areas of various project-related disturbances are the same as described for the pronghorn winter habitat model.

Sage Grouse Nesting Habitat Model. Table I.D-3 provides all component parts and their associated probabilities for the sage grouse nesting habitat model. Prior probabilities and conditional probabilities for 7 habitat conditions are defined, below.

Prior Probabilities: We assumed that areas within a 2-mile radius of any sage grouse lek (see Figure I.A-4 for known sage grouse leks and 2-mile radii on the PAPA), regardless of recent activity level, provided nesting habitats that were more suitable than marginal. Therefore, $P(S) = 0.60$ and $P(M) = 0.40$ were assigned. We also assumed that any area beyond the 2-mile radius provided some suitable habitats but were more marginal than suitable. In those areas, $P(S) = 0.40$ and $P(M) = 0.60$.

Vegetation Cover: Sage grouse nest on the ground. Successful sage grouse nests were in sagebrush stands with greater canopy cover than at unsuccessful nests (Pyrah, 1971). Martin (1976) found nesting sage grouse preferred sagebrush stands with 20-30 percent canopy cover and Wallestad and Pyrah (1974) documented mean canopy cover of 27 percent at successful nests but only 20 percent cover at unsuccessful nest sites. Shrub height is also important. Average height of sagebrush plants concealing nests were significantly taller than plants in the general vicinity (Colenso *et al.*, 1980). Other investigators also concluded that the tallest sagebrush at a particular site is selected for nesting (Braun *et al.*, 1977). And, nesting habitats are often within denser stands of sagebrush (Rasmussen and Griner, 1938; Patterson, 1952; Klebenow, 1969).

The following vegetation types were mapped within the PAPA: low density sagebrush, high density sagebrush, mixed grasslands, greasewood, desert shrub, riparian shrub and forest, irrigated cropland, barren ground, other limited types and human settlement. Of these, high density sagebrush was assumed to be most suitable for nesting sage grouse ($P(E|E) = 0.70$ and $P(E|M) = 0.20$). Low density sagebrush and greasewood-saltbush were assumed to be more marginal than suitable (Table I.D-3) and other types were given no probability of being sage grouse nesting habitat, either marginal or suitable ($P(E|S) = 0$ and $P(E|M) = 0$).

Distance To Brood-Rearing Habitat: Forb-producing areas are important as chicks grow older and replace diets mostly of insects with forbs (Leach and Hensley, 1954; Klebenow and Gray, 1968; Peterson, 1970; Wallestad, 1975; Martin, 1976). Forb-producing areas utilized by sage grouse include hay meadows, greasewood bottoms, stream banks, playas, and other areas of herbaceous vegetation (Rasmussen and Griner, 1938; Gill and Glover, 1965; Wallestad, 1971). Marked sage grouse in Colorado moved up to 7 miles from leks to summering areas (Gill and Glover, 1965). Although we found no definitive data linking distances from nests to brood-rearing areas, we assumed

Table I.D-2. Model for Mule Deer Winter Habitat.

Prior Probabilities:	Suitable	Marginal
Crucial WYL and Crucial WIN Range	0.60	0.30
Non-Crucial WYL and Non-Crucial WIN Range	0.40	0.70
Other Seasonal Ranges	0.00	0.00

Conditional Probabilities:	Suitable	Marginal
1. Vegetation cover:		
a. Low Density Sagebrush	0.40	0.20
b. Riparian	0.35	0.25
c. High Density Sagebrush	0.20	0.25
d. Other (Greasewood - Saltbush, Cropland - Pasture)	0.05	0.30
2. Topography:		
a. Drainages, Flat, Gentle slopes (≤ 10%)	0.40	0.25
c. Steep slopes (> 10% but < 25%)	0.35	0.30
d. Slopes > 25%	0.25	0.45
3. Slope Aspect:		
a. None (flat topography)	0.50	0.50
b. South and West (< 315° and > 135°)	0.30	0.15
c. North and East (> 315° and < 135°)	0.20	0.35
4. Elevation:		
a. < 0.5 x (Maximum Elevation + Minimum Elevation)	0.60	0.40
b. > 0.5 x (Maximum Elevation + Minimum Elevation)	0.40	0.60
5. Overlaps Elk and/or Pronghorn Winter Range:		
a. No	0.60	0.40
b. Yes	0.40	0.60
6. Livestock Grazing (All livestock classes):		
a. No grazing	0.60	0.40
b. Grazing	0.40	0.60
7. Distance to Nearest Road (Not 2-tracks), Well Pad, or Human Settlement:		
a. > 0.60 mile from road/well pad/house	0.70	0.40
b. ≤ 0.60 mile from road/well pad/house	0.30	0.60
8. Surface Disturbance:		
a. No	0.50	0.50
b. Yes	0.00	0.00

that all areas 5 miles or closer to suitable brood-rearing habitats (playas, wetlands, croplands and riparian zones) were more suitable for nesting sage grouse ($P(E|S)$ = 0.60 and $P(E|M)$ = 0.40) than areas greater than 5 miles ($P(E|S)$ = 0.40 and $P(E|M)$ = 0.60).

Distance to Water: In Utah, Rasmussen and Griner (1938) reported sage grouse were rarely found beyond 1 mile from water and in Wyoming, all nests of telemetered sage grouse were within 1.3 miles from open water (Hayden-Wing *et al.*, 1985). We assumed that all areas 1.5 miles or closer to water sources were more suitable for nesting sage grouse ($P(E|S)$ = 0.60 and $P(E|M)$ = 0.40) than areas greater than 1.5 miles ($P(E|S)$ = 0.40 and $P(E|M)$ = 0.60).

Slopes and Terrain: In general, sage grouse are most often found in flat or gently rolling topography (Call, 1974). In northeastern Wyoming, the majority of sage grouse nests were found on slopes less than 8 degrees, or less than 18 percent slopes (Hayden-Wing *et al.*, 1985). We assumed that all areas with slopes equal to or less than 10 percent were more suitable for nesting sage grouse ($P(E|S)$ = 0.60 and $P(E|M)$ = 0.30) than areas on steeper slopes greater than 10 percent ($P(E|S)$ = 0.40 and $P(E|M)$ = 0.70).

Livestock Grazing: Herbaceous vegetation ground cover at nest sites is an important component for use by sage grouse (Rasmussen and Griner, 1938; Hayden-Wing *et al.*, 1985). Areas of tall dense sagebrush without herbaceous understories have no value to sage grouse (Klebenow, 1969). Overgrazing by livestock has been identified as a potential factor causing declining sage grouse populations (Call, 1974; WGFD, 1991) since nests may not be adequately concealed. Removal of herbaceous vegetation, especially tall grasses, and medium height shrub vegetation cover near nest sites has been shown to increase risks of predation on sage grouse nests (Gregg *et al.*, 1994). We assumed that all areas grazed by livestock were less suitable for nesting sage grouse ($P(E|S)$ = 0.40 and $P(E|M)$= 0.60) than areas not grazed ($P(E|S)$ = 0.60 and $P(E|M)$ = 0.40).

Distance to Nearest Road or Well Pad: No information has been found that relates sage grouse nesting habitat suitability to distance from roads or well pads. However, reports indicate that mammals and birds will consistently escape from noises between 75 and 85 dBA (Golden *et al.*, 1980). Heavy machinery such as Mack trucks, scrapers and dozers typically emit noise levels within the 75 to 85 dBA range at distances beyond 200 feet. Passenger cars emit noises of 69-76 dBA at a distance of 50 feet and 51-58 dBA at 400 feet away (Golden *et al.*, 1980). Noise levels associated with drilling rigs, drill rig operations, and other well pad activities typically emit noise levels from 95 to 115 dBA at unmitigated source points and sound attenuation to EPA health and welfare levels (55 dBA) can range from 0.3 to 0.7 mile if no mufflers, sound screens, or sound absorbers are employed (Montana Board of Oil and Gas Conservation, 1989).

The presence of physical barriers, foliage and vegetation, wind, and daytime temperatures all affect noise attenuation and sound detection (Harrison, 1978). Ambient noise levels measured in sagebrush vegetation with wind speeds of 15-25 mph ranged from 43-57 dBA but ambient noise levels were 40-47 dBA with wind blowing 5-10 mph (Hayden-Wing Associates, 1991). Since noise levels decrease 6 dBA for every doubling of distance (Golden *et al.*, 1980), noises due to operating well-field equipment on roads or drill pads would probably decrease to ambient levels 0.15 mile (800 feet) away.

In addition, researchers have described a "dust shadow" that alters habitats beyond actual roads which reduce densities of ground-nesting birds (Hanley *et al.*, 1981). Road dust can also affect adjacent vegetation by causing snow to melt earlier (Klein, 1979), presumably by decreasing moisture availability that might otherwise be synchronous with plant growth phenology. Because of the effects of noise and fugitive dust, we assumed that all areas 0.15 mile or less from a road or well pad were less suitable for nesting sage grouse ($P(E|S)$ = 0.30 and $P(E|M)$ = 0.70) than areas beyond 0.15 mile of a road or well pad ($P(E|S)$ = 0.70 and $P(E|M)$ = 0.30).

Surface Disturbance: Any surface disturbance would remove vegetation and so make that site unusable for nesting by sage grouse. Consequently, levels of any other habitat condition would be totally negated and so conditional probabilities for both suitable and marginal habitat were set to zero. If no surface disturbance was present, conditional probabilities for suitable and marginal habitat were each set to 0.50 so that the effect of no surface disturbance would not counter effects of other habitat conditions. Maximum areas of surface disturbance that would apply to construction-related disturbances were the same as those used in the pronghorn winter habitat model.

Table I.D-3. Model for Sage Grouse Nesting Habitat.

Prior Probabilities:	Suitable	Marginal
≤ 2 miles from a lek	0.60	0.40
> 2 miles from a lek	0.40	0.60

Conditional Probabilities:	Suitable	Marginal
1. Vegetation cover:		
a. High density sagebrush	0.70	0.20
b. Low density sagebrush	0.25	0.30
c. Other shrub (greasewood-saltbush)	0.05	0.50
d. Other Vegetation Types (crops, grasslands, riparian)	0.00	0.00
2. Distance to brood-rearing habitat:		
a. ≤ 5 miles from playa, wetland, riparian, meadow	0.60	0.40
b. > 5 miles from playa, wetland, riparian, meadow	0.40	0.60
3. Distance to available water:		
a. ≤ 1.5 mile from water	0.60	0.40
b. > 1.5 mile from water	0.40	0.60
4. Slopes/Terrain:		
a. (≤ 10% slope) Flat to gentle slopes	0.60	0.30
b. (> 10% slope) Steep slopes	0.40	0.70
5. Livestock Grazing:		
a. No grazing	0.60	0.40
b. Grazing	0.40	0.60
6. Distance to Nearest Road (Not 2-tracks), Well Pad, or Human Settlement:		
a. > 0.15 mile (800 ft) from road/well pad/house	0.70	0.30
b. ≤ 0.15 mile (800 ft) from road/well pad/house	0.30	0.70
7. Surface Disturbance:		
a. No	0.50	0.50
b. Yes	0.00	0.00

E. EXAMPLES OF MODEL APPLICATION IN CUMULATIVE IMPACT ANALYSIS

Pronghorn Winter Habitat Model. An example is provided below of calculations in the Bayesian Probability model for pronghorn winter range habitat. The example is applied with the prior probabilities and conditional probabilities for 8 environmental conditions defined in Table I.D-1, above. Two examples of how the model can be used to evaluate cumulative impacts to pronghorn winter habitat are also provided in Table I.E-1 and Table I.E-2. In those examples, effects due to livestock, human settlements, roads and well pads, and surface disturbances are removed to model potential habitat conditions. The model provides probabilities of suitable and marginal habitat under existing conditions and with components associated with a new project. Posterior probabilities for suitable and marginal habitat associated with the new project plus existing conditions represent cumulative impacts when compared to probabilities derived for potential habitat conditions.

Example Calculations:

Prior Probabilities: Area is within Crucial Winter-Yearlong Range: Prior Probabilities are $P(S) = 0.55$, $P(M) = 0.45$.

Condition 1, Vegetation Cover: Area is covered by low density sagebrush: Conditional Probabilities are $P(E|S) = 0.30$, $P(E|M) = 0.20$.

Condition 2, Topography: Area is on 5% slope: Conditional Probabilities are $P(E|S) = 0.35$, $P(E|M) = 0.25$.

Condition 3, Slope Aspect: Area is on south-facing slope: Conditional Probabilities are $P(E|S) = 0.35$, $P(E|M) = 0.30$.

Condition 4, Elevation: Area is in lower elevation: Conditional Probabilities are $P(E|S) = 0.60$, $P(E|M) = 0.40$.

Condition 5, Overlaps Any Elk or Mule Deer Winter Range: Area overlaps mule deer winter range: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

Condition 6, Grazing by Livestock: Area is grazed by cattle: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

Condition 7, Distance to Nearest Road, Well Pad or Human Settlement: Area is less than 0.60 mile from a road: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

Condition 8, Surface Disturbance: No surface disturbance in area: Conditional Probabilities are $P(E|S) = 0.50$, $P(E|M) = 0.50$.

Computation of posterior probability for suitable habitat $P(S|E)$ and posterior probability for marginal habitat $P(M|E$, given the above environmental conditions and conditional probabilities, $P(E|S)$ and $P(E|M)$:

$$P(S|E) = \frac{(0.55)(0.30 \times 0.35 \times 0.35 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.50)}{(0.55)(0.30 \times 0.35 \times 0.35 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.50) + (0.45)(0.20 \times 0.25 \times 0.30 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}$$

$P(S|E) = 0.57$, and

$$P(M|E) = \frac{(0.45)(0.20 \times 0.25 \times 0.30 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}{(0.55)(0.30 \times 0.35 \times 0.35 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.50) + (0.45)(0.20 \times 0.25 \times 0.30 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}$$

$P(M|E) = 0.43$.

In this example, the posterior probability is 0.57 (57% probable) that the environmental conditions in the area provide suitable winter habitat for pronghorns with only a probability of 0.43 (43% probable) that it is marginal habitat. The initial prior probabilities were 0.55 of being suitable and 0.45 of being marginal. So, the environmental conditions present at the location reinforce the intial evaluation that the parcel is more likely to be suitable than marginal winter habitat: one would expect to find pronghorns utilizing habitat on the site during winter.

Table I.E-1. First example of applying the pronghorn winter habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	Parameter Value: Potential Conditions	Parameter Value: Existing Conditions	Parameter Value: With New Project	Suitable-Marginal Probability	Conditional Probabilities: Potential Conditions	Conditional Probabilities: Existing Conditions	Conditional Probabilities: With New Project
1. Vegetation cover	*High density sagebrush*	*High density sagebrush*	*High density sagebrush*	Suitable	*0.35*	*0.35*	*0.35*
				Marginal	*0.20*	*0.20*	*0.20*
2. Topography	*Slope 15%*	*Slope 15%*	*Slope 15%*	Suitable	*0.45*	*0.45*	*0.45*
				Marginal	*0.25*	*0.25*	*0.25*
3. Slope aspect	*Northeast*	*Northeast*	*Northeast*	Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.25*	*0.25*	*0.25*
4. Elevation	*Lower half*	*Lower half*	*Lower half*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
5. Winter range overlap	*No*	*No*	*No*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
6. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
7. Distance to nearest road/well pad/house	*> 0.60 mile*	*> 0.60 mile*	*0.30 mile*	Suitable	*0.60*	*0.60*	*0.40*
				Marginal	*0.40*	*0.40*	*0.60*
8. Surface disturbance	*No*	*No*	*No*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
PRIOR PROBABILITIES				Suitable	*0.45*	*0.45*	*0.45*
				Marginal	*0.60*	*0.60*	*0.60*
POSTERIOR PROBABILITIES				Suitable	*0.95*	*0.89*	*0.79*
				Marginal	*0.05*	*0.11*	*0.21*

Table I.E-2. Second example of applying the pronghorn winter habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	Parameter Value			Suitable-Marginal Probability	Conditional Probabilities		
	Potential Conditions	Existing Conditions	With New Project		Potential Conditions	Existing Conditions	With New Project
1. Vegetation cover	*Low density sagebrush*	*Low density sagebrush*	*Low density sagebrush*	Suitable	*0.30*	*0.30*	*0.30*
				Marginal	*0.20*	*0.20*	*0.20*
2. Topography	*Flat*	*Flat*	*Flat*	Suitable	*0.20*	*0.20*	*0.20*
				Marginal	*0.50*	*0.50*	*0.50*
3. Slope aspect	*None*	*None*	*None*	Suitable	*0.25*	*0.25*	*0.25*
				Marginal	*0.45*	*0.45*	*0.45*
4. Elevation	*Lower half*	*Lower half*	*Lower half*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
5. Winter range overlap	*No*	*No*	*No*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
6. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
7. Distance to nearest road/well pad/house	*> 0.60 mile*	*> 0.60 mile*	*0.30 mile*	Suitable	*0.60*	*0.60*	*0.40*
				Marginal	*0.40*	*0.40*	*0.60*
8. Surface disturbance	*No*	*No*	*No*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
PRIOR PROBABILITIES				Suitable	*0.55*	*0.55*	*0.55*
				Marginal	*0.40*	*0.40*	*0.40*
POSTERIOR PROBABILITIES				Suitable	*0.70*	*0.51*	*0.31*
				Marginal	*0.30*	*0.49*	*0.69*

Similar computations are required to derive the posterior probabilities shown in the two examples of cumulative impacts in Table I.E-1 and Table I.E-2. The first example in Table I.E-1 shows that the area is on non-crucial WYL range but, under potential conditions, the habitat characteristics are such that the model predicts an extremely high probability that it is suitable winter range, $P(S|E) = 0.95$. Existing conditions with livestock grazing have slightly decreased the probability of the parcel being suitable pronghorn winter habitat to $P(S|E) = 0.89$. The new project involves construction of a road 0.3 mile from the area. The area is still probably suitable winter habitat, albeit with a lower probability $P(S|E) = 0.79$, even with the influence of the road and livestock grazing.

In the second example shown in Table I.E-2, the area is within crucial WYL range but with potential habitat conditions less than optimal. The model predicts the potential habitat conditions in the area make it suitable winter habitat with $P(S|E) = 0.70$ but that existing conditions have reduced that probability to $P(S|E) = 0.51$ because of livestock grazing. Thus, the model predicts that existing conditions make the area barely more suitable than marginal as pronghorn winter habitat. As in the first example, the new project involves construction of a road 0.3 mile from the area which the model predicts will greatly decrease the probability that the area is suitable winter habitat, $P(S|E) = 0.31$ and that it is more likely to be marginal habitat, $P(M|E) = 0.69$.

Mule Deer Winter Habitat Model. An example is provided below of calculations in the Bayesian Probability model for mule deer winter habitat. The example is applied with the prior probabilities and conditional probabilities for 8 environmental conditions defined in Table I.D-2, above. Two examples of how the model can be used to evaluate cumulative impacts to mule deer winter habitat are also provided in Table I.E-3 and Table I.E-4. In those examples, effects due to livestock, roads and well pads, and surface disturbances are removed to model potential habitat conditions. The model provides probabilities of suitable and marginal habitat under existing conditions and with components associated with a new project. Posterior probabilities for suitable and marginal habitat associated with the new project plus existing conditions represent cumulative impacts when compared to probabilities derived for potential habitat conditions.

Example Calculations:

<u>Prior Probabilities:</u> Area is within Crucial Winter-Yearlong Range: Prior Probabilities are $P(S) = 0.60$, $P(M) = 0.30$.

<u>Condition 1, Vegetation Cover:</u> Area is covered by low density sagebrush: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.20$.

<u>Condition 2, Topography:</u> Area is on greater than 10% slope: Conditional Probabilities are $P(E|S) = 0.35$, $P(E|M) = 0.30$.

<u>Condition 3, Slope Aspect:</u> Area is on south-facing slope: Conditional Probabilities are $P(E|S) = 0.30$, $P(E|M) = 0.15$.

<u>Condition 4, Elevation:</u> Area is in lower elevation: Conditional Probabilities are $P(E|S) = 0.60$, $P(E|M) = 0.40$.

<u>Condition 5, Overlaps Any Elk or Pronghorn Winter Range:</u> Area overlaps pronghorn winter range: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

<u>Condition 6, Livestock Grazing:</u> Area is grazed by livestock: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

<u>Condition 7, Distance to Nearest Road, Well Pad or Human Settlement:</u> Area is less than 0.60 mile from a road: Conditional Probabilities are $P(E|S) = 0.30$, $P(E|M) = 0.60$.

<u>Condition 8, Surface Disturbance:</u> No surface disturbance in area: Conditional Probabilities are $P(E|S) = 0.50$, $P(E|M) = 0.50$.

Computation of posterior probability for suitable habitat $P(S|E)$ and posterior probability for marginal habitat $P(M|E)$, given the above environmental conditions and conditional probabilities, $P(E|S)$ and $P(E|M)$:

$$P(S|E) = \frac{(0.60)(0.40 \times 0.35 \times 0.30 \times 0.60 \times 0.40 \times 0.40 \times 0.30 \times 0.50)}{(0.60)(0.40 \times 0.35 \times 0.30 \times 0.60 \times 0.40 \times 0.40 \times 0.30 \times 0.50) + (0.30)(0.20 \times 0.30 \times 0.15 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}$$

$P(S|E) = 0.76$, and

$$P(M|E) = \frac{(0.30)(0.20 \times 0.30 \times 0.15 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}{(0.60)(0.40 \times 0.35 \times 0.30 \times 0.60 \times 0.40 \times 0.40 \times 0.30 \times 0.50) + (0.30)(0.20 \times 0.30 \times 0.15 \times 0.40 \times 0.60 \times 0.60 \times 0.60 \times 0.50)}$$

$P(M|E) = 0.24$.

In this example, the posterior probability is 0.76 (76% probable) that the environmental conditions in the area provide suitable winter habitat for mule deer with only a probability of 0.24 (24% probable) that it is marginal habitat. The initial prior probabilities were 0.60 (60% likely) of being suitable with a 30% chance of being marginal habitat. The environmental conditions present at the site increase the likelihood that mule deer would occur there than originally thought.

Similar computations are required to derive the posterior probabilities shown in the two examples of cumulative impacts in Table I.E-3 and Table I.E-4. The first example in Table I.E-3 shows that existing conditions have slightly decreased the probability of the area being suitable mule deer winter habitat from $P(S|E) = 0.96$ under potential conditions to $P(S|E) = 0.92$. This slight decline is the result of livestock grazing under existing conditions. The new project involves construction of a road 0.3 mile from the area. The area is still probably suitable winter habitat, albeit with a lower probability $P(S|E) = 0.77$, even with the influence of the road and livestock grazing.

In Table I.E-4, potential habitat conditions reveal that the area is suitable winter habitat with $P(S|E) = 0.88$ and that existing conditions have reduced that probability to $P(S|E) = 0.77$ because of livestock grazing. As in the first example, the new project involves construction of a road 0.3 mile from the area. But in this example, the area less likely to be suitable than marginal habitat with $P(S|E) = 0.49$ and $P(M|E) = 0.51$. The different effects due to the same cumulative impacts in the two examples are dependent on all other habitat attributes that make the first area highly suitable but the second area less so: cumulative impacts have greater effects on sub-optimal habitats than on areas with nearly optimal habitat conditions.

Sage Grouse Nesting Habitat Model. An example is provided below of calculations in the Bayesian Probability model for sage grouse nesting habitat. The example is applied with the prior probabilities and conditional probabilities for 7 environmental conditions defined in Table I.D-3, above. Two examples of how the model can be used to evaluate cumulative impacts to sage grouse nesting habitat are also provided in Table I.E-5 and Table I.E-6. In those examples, effects due to livestock, roads and well pads, and surface disturbances are removed to model potential habitat conditions. The model provides probabilities of suitable and marginal habitat under existing conditions and with components associated with a new project. Posterior probabilities for suitable and marginal habitat associated with the new project plus existing conditions represent cumulative impacts when compared to probabilities derived for potential habitat conditions.

Example Calculations:

<u>Prior Probabilities:</u> Area is within 2 miles of a known lek: Prior Probabilities are $P(S) = 0.60$, $P(M) = 0.40$.

<u>Condition 1, Vegetation Cover:</u> Area is covered by high density sagebrush: Conditional Probabilities are $P(E|S) = 0.70$, $P(E|M) = 0.20$.

<u>Condition 2, Distance to Brood-Rearing Habitat:</u> Area is within 5 miles of brood-rearing habitat: Conditional Probabilities are $P(E|S) = 0.60$, $P(E|M) = 0.40$.

<u>Condition 3, Distance to Available Water:</u> Distance to water is greater than 1.5 miles: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

<u>Condition 4, Slopes/Terrain:</u> Area is on a steep slope, greater than 10%: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.70$.

Table I.E-3. First example of applying the mule deer winter habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	Parameter Value: Potential Conditions	Parameter Value: Existing Conditions	Parameter Value: With New Project	Suitable-Marginal Probability	Conditional Probabilities: Potential Conditions	Conditional Probabilities: Existing Conditions	Conditional Probabilities: With New Project
1. Vegetation cover	*Riparian*	*Riparian*	*Riparian*	Suitable	*0.35*	*0.35*	*0.35*
				Marginal	*0.25*	*0.25*	*0.25*
2. Topography	*Flat*	*Flat*	*Flat*	Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.25*	*0.25*	*0.25*
3. Slope aspect	*None*	*None*	*None*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
4. Elevation	*Lower half*	*Lower half*	*Lower half*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
5. Winter range overlap	*No*	*No*	*No*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
6. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
7. Distance to nearest road/well pad/house	*> 0.6 mile*	*> 0.6 mile*	*0.3 mile*	Suitable	*0.70*	*0.70*	*0.30*
				Marginal	*0.40*	*0.40*	*0.60*
8. Surface disturbance	*No*	*No*	*No*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
PRIOR PROBABILITIES				Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.30*	*0.30*	*0.30*
POSTERIOR PROBABILITIES				Suitable	*0.96*	*0.92*	*0.77*
				Marginal	*0.04*	*0.08*	*0.23*

Table I.E-4. Second example of applying the mule deer winter habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	Parameter Value			Suitable-Marginal Probability	Conditional Probabilities		
	Potential Conditions	Existing Conditions	With New Project		Potential Conditions	Existing Conditions	With New Project
1. Vegetation cover	*Riparian*	*Riparian*	*Riparian*	Suitable	*0.35*	*0.35*	*0.35*
				Marginal	*0.25*	*0.25*	*0.25*
2. Topography	*Flat*	*Flat*	*Flat*	Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.25*	*0.25*	*0.25*
3. Slope aspect	*None*	*None*	*None*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
4. Elevation	*Lower half*	*Lower half*	*Lower half*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
5. Winter range overlap	*No*	*No*	*No*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
6. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
7. Distance to nearest road/well pad/house	*> 0.6 mile*	*> 0.6 mile*	*0.3 mile*	Suitable	*0.70*	*0.70*	*0.30*
				Marginal	*0.40*	*0.40*	*0.60*
8. Surface disturbance	*No*	*No*	*No*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
PRIOR PROBABILITIES				Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.70*	*0.70*	*0.70*
POSTERIOR PROBABILITIES				Suitable	*0.88*	*0.77*	*0.49*
				Marginal	*0.11*	*0.23*	*0.51*

<u>Condition 5, Livestock Grazing:</u> Area is grazed by livestock: Conditional Probabilities are $P(E|S) = 0.40$, $P(E|M) = 0.60$.

<u>Condition 6, Distance to Nearest Road, Well Pad or Human Settlement:</u> Area is less than 0.15 mile (800 ft) from a road: Conditional Probabilities are $P(E|S) = 0.30$, $P(E|M) = 0.70$.

<u>Condition 7, Surface Disturbance:</u> No surface disturbance in area: Conditional Probabilities are $P(E|S) = 0.50$, $P(E|M) = 0.50$.

Computation of posterior probability for suitable habitat $P(S|E)$ and posterior probability for marginal habitat $P(M|E)$, given the above environmental conditions and conditional probabilities, $P(E|S)$ and $P(E|M)$:

$$P(E|S) = \frac{(0.60)\,(0.70 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.30 \times 0.50)}{(0.60)\,(0.70 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.30 \times 0.50) + (0.40)\,(0.20 \times 0.40 \times 0.60 \times 0.70 \times 0.60 \times 0.70 \times 0.50)}$$

$P(S|E) = 0.46$, and

$$P(M|E) = \frac{(0.40)\,(0.20 \times 0.40 \times 0.60 \times 0.70 \times 0.60 \times 0.70 \times 0.50)}{(0.60)\,(0.70 \times 0.60 \times 0.40 \times 0.40 \times 0.40 \times 0.30 \times 0.50) + (0.40)\,(0.20 \times 0.40 \times 0.60 \times 0.70 \times 0.60 \times 0.70 \times 0.50)}$$

$P(M|E) = 0.54$.

In this example, the posterior probability is 0.46 (46% probable) that the environmental conditions in the area provide suitable nesting habitat for sage grouse and is more likely to be marginal nesting habitat with probability of 0.54 (54% probable). Because the locale is within 2 miles of a lek, the prior probability was 0.60 (60% likely) that it is suitable nesting habitat. But environmental conditions are such that it is less likely to be suitable than marginal: one would not expect to find sage grouse nesting in the area.

Similar computations are required to derive the posterior probabilities shown in the two examples of cumulative impacts in Table I.E-5 and Table I.E-6. In both examples, potential habitat conditions indicate the two areas provide nearly optimal habitat for nesting sage grouse with probabilities for suitable habitat of $P(S|E) = 0.94$ and $P(S|E) = 0.95$, respectively. Existing conditions in the first example have slightly decreased nesting habitat suitability ($P(S|E) = 0.88$) since livestock grazing is the only existing impact. But in the second example, livestock grazing and a house constructed 0.1 mile away have decreased suitability even though the area is suitable with posterior probability $P(S|E) = 0.62$, nearly identical to the prior probability $P(S) = 0.60$. Cumulative effects of new projects will always be most deleterious if surface disturbances occur, as in the second example, Table I.E-6.

Table I.E-5. First example of applying the sage grouse nesting habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	Parameter Value			Suitable-Marginal Probability	Conditional Probabilities		
	Potential Conditions	Existing Conditions	With New Project		Potential Conditions	Existing Conditions	With New Project
1. Vegetation cover	*Dense sagebrush*	*Dense sagebrush*	*Dense sagebrush*	Suitable	*0.70*	*0.70*	*0.70*
				Marginal	*0.20*	*0.20*	*0.20*
2. Distance to brood -rearing habitat	*5 miles*	*5 miles*	*5 miles*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
3. Distance to available water	*2 miles*	*2 miles*	*2 miles*	Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.60*	*0.60*	*0.60*
4. Slopes/Terrain	*Gentle*	*Gentle*	*Gentle*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.30*	*0.30*	*0.30*
5. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
6. Distance to nearest road/well pad/house	*> 0.15 mile*	*0.5 mile*	*0.1 mile*	Suitable	*0.70*	*0.70*	*0.30*
				Marginal	*0.30*	*0.30*	*0.70*
7. Surface disturbance	*No*	*No*	*No*	Suitable	*0.50*	*0.50*	*0.50*
				Marginal	*0.50*	*0.50*	*0.50*
PRIOR PROBABILITIES				Suitable	*0.40*	*0.40*	*0.40*
				Marginal	*0.60*	*0.60*	*0.60*
POSTERIOR PROBABILITIES				Suitable	*0.94*	*0.88*	*0.57*
				Marginal	*0.06*	*0.12*	*0.43*

Table I.E-6. Second example of applying the sage grouse nesting habitat model to estimate potential habitat conditions, existing conditions, and cumulative conditions with a new project. Fictitious parameter values are provided.

PARAMETER	**Parameter Value**			**Suitable-Marginal Probability**	**Conditional Probabilities**		
	Potential Conditions	**Existing Conditions**	**With New Project**		**Potential Conditions**	**Existing Conditions**	**With New Project**
1. Vegetation cover	*Low sagebrush*	*Low sagebrush*	*Low sagebrush*	Suitable	*0.25*	*0.25*	*0.25*
				Marginal	*0.30*	*0.30*	*0.30*
2. Distance to brood -rearing habitat	*4 miles*	*4 miles*	*4 miles*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
3. Distance to available water	*1 mile*	*1 mile*	*1 mile*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
4. Slopes/Terrain	*Gentle*	*Gentle*	*Gentle*	Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.30*	*0.30*	*0.30*
5. Livestock grazing	*No*	*Yes*	*Yes*	Suitable	*0.60*	*0.40*	*0.40*
				Marginal	*0.40*	*0.60*	*0.60*
6. Distance to nearest road/well pad/house	*> 0.15 mile*	*0.1 mile*	*0.0 mile*	Suitable	*0.70*	*0.30*	*0.30*
				Marginal	*0.30*	*0.70*	*0.70*
7. Surface disturbance	*No*	*No*	*Yes*	Suitable	*0.50*	*0.50*	*0.00*
				Marginal	*0.50*	*0.50*	*0.00*
PRIOR PROBABILITIES				Suitable	*0.60*	*0.60*	*0.60*
				Marginal	*0.40*	*0.40*	*0.40*
POSTERIOR PROBABILITIES				Suitable	*0.95*	*0.62*	*0.00*
				Marginal	*0.05*	*0.38*	*0.00*

F. CUMULATIVE IMPACTS WITHIN THE PAPA

The entire 308 square mile (197,345 acres) PAPA was evaluated for potential and existing habitat conditions with each of the three habitat models (Section D) using GIS and the data layers or their transformations described in Section C. The models were also used to evaluate the effects of simulations within four areas along the Pinedale Anticline Crest (Figure 1.D-1) that, together with existing conditions, provide a measure of potential cumulative impacts within the PAPA.

Potential and Existing Habitat Conditions in the PAPA. Portions of the entire PAPA that each model evaluated as suitable habitat under potential conditions and existing conditions shown in Table I.F-1. In each case, the amount of suitable habitat under potential conditions decreased under existing conditions. There is less pronghorn and mule deer winter habitat in the 308-square mile PAPA than sage grouse nesting habitat. Within the PAPA there are approximately 120 acres of non-crucial pronghorn WIN range (0.06 percent of the PAPA) and 47,426 acres of crucial WIN range (24.0 percent) as delineated by WGFD. Both ranges are expected to provide winter habitat for pronghorns. The pronghorn winter habitat model predicted that 43,759 acres, or 22.2 percent of the PAPA would be suitable habitat (with probabilities of greater than 50%) under potential conditions (Table I.F-1 and see Figure I.F-1). When the modeled effects of existing roads, well pads, human settlements, other surface disturbance, and livestock grazing are included in the modeling process, only 17.3 percent of the PAPA (34,066 acres) would be suitable pronghorn winter habitat (Table I.F-1 and see Figure I.F-2). The model clearly indicates that existing conditions with human influences have reduced the amount of suitable pronghorn winter habitat in the PAPA from what would be expected under potential conditions (Figure I.F-1).

Within the PAPA there are 14,465 acres of non-crucial mule deer WYL range, 27,220 acres of crucial WIN and 26,131 acres of WIN mule deer range managed by BLM as crucial range. Taken together, these ranges total 67,816 acres, approximately 34.4 percent of the PAPA. The model of mule deer winter habitat predicts that existing conditions within the PAPA produce 39,641 acres that have probabilities of greater than 50 percent of being suitable habitat. That amounts to 20.1 percent of the PAPA (Table I.F-1 and Figure I.F-4). However, when the effects of roads, human settlements, other surface disturbances and livestock grazing are removed, potential habitat conditions evaluated by the model indicate that 60,378 acres or 30.6 percent of the PAPA (Figure I.F-3) are probably suitable for mule deer winter habitat use (Table I.F-1). According to the two modeling outcomes, existing disturbances within the PAPA have reduced areas of habitats likely to be suitable for wintering mule deer by 34.3 percent.

When used to evaluate existing conditions, the model of sage grouse nesting habitat predicted that 142,324 acres within the PAPA have probabilities of greater than 50 percent of being suitable sage grouse nesting habitats (Table I.F-1, Figure I.F-6). This is approximately 72.1 percent of the total PAPA in which, under existing conditions, one would expect to find nesting sage grouse. However, when the effects of existing roads and well pads, existing surface disturbances, human settlements and livestock grazing are removed, potential habitat conditions evaluated by the model indicate that 158,698 acres within the PAPA (80.4 percent of the area) are probably suitable for sage grouse to use for nesting (Figure I.F-5). The two modeling outcomes indicate that existing disturbances and land use within the PAPA have reduced areas of potential nesting habitats that are probably suitable for sage grouse by 10.3 percent.

While habitat modeling of potential conditions probably does not reflect habitat suitability during pristine conditions, comparisons of potential to existing conditions can provide managers with various options for habitat treatment projects. By examining graphic distributions of areas of suitable habitats under potential and existing conditions shown for pronghorn winter habitat in Figure I.F-1 and Figure I.F-2, for mule deer winter habitat in Figure I.F-3 and Figure I.F-4, and sage grouse nesting habitat in Figure I.F-5 and Figure I.F-6, one could determine which sites and which wildlife habitats on the PAPA would benefit most from some kind of treatment, for example, reclamation of an unnecessary road.

Model Simulations on the Pinedale Anticline Crest. Four zones along the Pinedale Anticline (Figure I.D-1) were defined as areas with high interest for natural gas exploration and/or development. Together, these total 34,243 acres and overlap pronghorn and mule deer winter ranges (Figure I.A-2 and Figure I.A-3, respectively) and sage grouse nesting areas (areas within 2 miles of leks, Figure I.A-4). Although exact locations of well pads cannot be determined anywhere on the PAPA, well pad development within these four zones appear to be highly likely. Therefore, three scenarios were developed to simulate the effects of well pad locations on wildlife habitats. Well pad densities of 4 pads per section, 8 pads per section, and 16 pads per section were applied to these four areas on the

Table I.F-1. Areas (acres and percent of total) of the PAPA predicted to be suitable habitats within various probability levels by three wildlife habitat models under potential and existing habitat conditions.

Suitable Habitat Probability	Pronghorn Winter Habitat Model				Mule Deer Winter Habitat Model				Sage Grouse Nesting Habitat Model			
	Potential Habitat Conditions (1)		Existing Habitat Conditions (2)		Potential Habitat Conditions		Existing Habitat Conditions		Potential Habitat Conditions		Existing Habitat Conditions	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent
0.91 to 1.00	20,999	10.64	2,996	1.52	15,256	7.73	4,386	2.22	110,155	55.82	68,198	34.56
0.81 to 0.90	15,202	7.70	9,367	4.75	21,101	10.69	6,614	3.35	24,148	12.24	31,606	16.02
0.71 to 0.80	4,475	2.27	10,154	5.15	13,395	6.79	12,617	6.39	14,943	7.57	22,481	11.39
0.61 to 0.70	1,576	0.80	5,567	2.82	7,443	3.77	2,918	1.48	136	0.07	15,063	7.63
0.51 to 0.60	1,507	0.76	5,982	3.03	3,183	1.61	13,106	6.64	9,316	4.72	4,976	2.52
0.01 to 0.50	3,787	1.92	13,050	6.61	7,438	3.77	27,581	13.98	2,164	1.09	17,085	8.66
0	149,800	75.91	150,230	76.12	129,530	65.64	130,124	65.94	36,484	18.49	37,937	19.22

notes:
1 = Assumes total PAPA with no livestock grazing, no roads, human settlements or other surface disturbances.
2 = Assumes following existing conditions: livestock graze in all allotments as reported by BLM, existing roads/well pads and human settlements are as determined with maximum surface disturbances.

Pinedale Anticline Crest in arrangements to avoid all areas where BLM would not allow well pad placement on Federal lands and minerals. Model simulation was only for effects of well pads and did not include any effects of roads and pipelines.

Under existing conditions, 2,139 acres (6.2 percent of the four areas) would be suitable pronghorn winter habitat with moderate to high probability (probabilities greater than 0.50, Table I.F-2). If 16 well pads/section were developed in these areas, a development level that would be possible under the Standard Stipulations Alternative discussed in the EIS, the amount of suitable pronghorn winter habitat would only be 1,865 acres (5.4 percent of the four simulation areas, 48.3 percent of pronghorn crucial winter habitat). That simulation does not include any effects of roads on habitat suitability but represents a 12.8 percent decrease from existing conditions.

Similarly, effects of 4 well pads per section and 8 pads per section were simulated and applied to all land within the four simulation areas on the Anticline Crest, not just Federal lands and lands with Federally-owned minerals. Even though the pronghorn winter habitat model was not designed to discriminate effects of roads or well pads closer together than 0.6 mile, well pads densities of 4 pads per section would result in only 1,986 acres (6 percent of the four areas) to be suitable winter habitat (Table I.F-2).

Development of centralized production facilities (CPF) in any of the big game wintering and sage grouse nesting habitats has the potential to increase short-term impacts: up to 16 well pads per section could be developed on any area on which BLM stipulations and/or resource protection measures fully prohibit surface disturbances. Each CPF would disturb 5 acres over the short- and long-term. However, each of the production well pads developed under this plan could be reclaimed to where only 0.5 acre would remain disturbed over the long-term. Also, human presence at each of the production well pads would be reduced or nearly eliminated over the long-term.

The potential effects by the CPF option to pronghorn and mule deer winter habitat and sage grouse nesting habitat were evaluated with the models first with one, then with two CPFs per section. In each case, densities of 16 well pads per section were assumed, each disturbing 3.7 acres. But, the so-called "zones of effect" only were modeled at the one or two CPFs and not around the other 14 or 15 production well pads in each section within the simulation area.

If one CPF would be developed in each section on the Anticline Crest simulation area, the pronghorn winter habitat model evaluated 1,875 acres of the area (Table I.F-2) as being suitable winter habitat (5.5 percent of the simulation area; 48.6 percent of pronghorn crucial range). With 2 CPFs, 1,865 acres would be suitable winter habitat habitat (5.4 percent of the simulation area; 48.3 percent of pronghorn crucial range). Since the small simulation area intersected by pronghorn crucial winter range is rated as relatively poor habitat under existing conditions, any development under any alternative option produces little additional degradation to that habitat in the simulation area.

Under potential mule deer winter habitat conditions, 8,333 acres (24 percent of the simulation areas) would be suitable habitat and 3,972 acres (12 percent of the simulation area, 42 percent of the mule deer winter habitat) under existing conditions would be suitable winter habitat with probabilities greater than 50 percent (Table I.F-3). As in the pronghorn winter habitat model, the mule deer model cannot effectively evaluate the effects of roads or well pads that are closer together than 0.6 mile. Even so, if 16 well pads per section were developed in these areas, the amount of suitable mule deer winter habitat likely to remain would only be 2,637 acres (8 percent of the simulation area, 28 percent of the winter habitat). That simulation does not include any effects of roads or pipelines on habitat suitability. And, simulation of 4 well pads per section spacing results in only 2,860 acres of suitable mule deer winter habitat, a decrease of 28 percent from existing conditions.

The mule deer winter habitat model was also used to evaluate effects of one and two CPFs. With one CPF per section, the model evaluated 3,567 acres within the simulation areas as suitable winter habitat (10 percent of the simulation areas, 38 percent of mule deer winter range). With 2 CPFs per section, 3,528 acres would be suitable winter habitat (10 percent of the simulation area, 37 percent of the deer winter range.

Potentially, sage grouse nesting habitat covers much more of the four areas on the Anticline Crest than either pronghorn or mule deer winter habitat. Under potential conditions, the sage grouse nesting habitat model evaluated 29,534 acres (86 percent of the four areas) as nesting habitat with probabilities greater than zero (Table I.F-4). Except for 84 acres, all would most likely be suitable nesting habitat. With existing conditions, 25,588 acres were modeled as suitable nesting habitat (with probabilities greater than 50 percent). Unlike the pronghorn and mule deer winter range models, the sage grouse nesting habitat model can discriminate effects of roads and well pads as close together as 800 feet (0.15 mile). Consequently, there are substantial differences in the amount of suitable habitat between simulations of the three well pad density possibilities shown in Table I.F-4. With 4 well pads per section, the amount of suitable nesting habitat is 19,999 acres but only 14,014 acres would be suitabel with 16 well pads per section, decreases of 22 percent and 45 percent, respectively from suitable habitat under existing conditions. These simulations do not include any effects of roads in the four high interest areas.

Model simulation with one CPF per section resulted in 22,164 acres in the simulation area as suitable nesting habitat (65 percent of the simulation area, 75 percent of nesting areas). With 2 CPFs per section, 20,955 acres would be suitable habitat (61 percent of the simulation area, 71 percent of nesting area).

Conclusion. Cumulative impact analyses, as described in this report, can only be accomplished with data accumulated for a large area including remote sensing, GIS spatial analyses, and habitat models. The approach used provides an evaluation of cumulative impacts in terms of habitat suitabilities, possibly analogous to habitat function, that has direct application to the analytical focus taken by WGFD's Mitigation Policy (see Section A). The analyses clearly reveal that existing and projected land use changes will decrease functional habitat for the three wildlife species considered.

The results beg the questions of wildlife and land managers of whether there has already been or will be too much loss of suitable habitat (to a point where habitat function is so impaired that populations can not be supported at some desired level) and if so, what mitigation efforts would be necessary and where they should be implemented to restore affected habitats. If the approach taken here is used to answer these questions, then the models will have achieved the duel objectives of assisting managers in making better decisions and helping to understand how the system works (Conroy, 1993). In both respects, these models or their modifications can provide managers with mitigation possibilities that can be evaluated for optimal effects with available funds (see Williams *et al.*, 1977 and Evans, 1984).

Specifically, managers can consider the following:

1. The wildlife habitat models should be revised with new biological information that is currently being collected on the PAPA and vicinity, or studies conducted elsewhere that provide relevant information. If or when that information shows that probability levels derived from animal habitat selection differs from levels currently employed in the models, the new information should be integrated in the models to increase their predictability of habitat evaluations.

2. The GIS layers used to catalog wildlife habitat data used in the modeling process should be maintained and updated as geographic and biological features change in terms of human settlements, topography, vegetation, use by domestic livestock and other herbivores.

3. As new roads, well pads, pipelines and other well field facilities are developed, their locations need to be digitized and included in GIS layers so that the wildlife habitat models can be used to continually evaluate the status of habitats on the PAPA.

4. Through continual reiterations with new biological and well field development data, the models should allow managers to identify site-specific opportunities for mitigation, whether through habitat enhancement, changes in land use or avoidance of new impacts altogether.

The models described here need to be reviewed by wildlife authorities to determine if weak or questionable model components could be improved (USFWS, 1981). Key criteria for any successful model include biological realism (the model should be connected to biological theory or hypothesis that represents some level of understanding), some degree of precision (the model should explain and predict real world phenomena), and some means of validation (Conroy, 1993). Validating the models with field data and subsequent model modification (USFWS, 1981; Morrison *et al.*, 1992; Conroy, 1993) are key steps in achieving model objectives that are too often ignored. But validation with feedback should be a continuous part of the process if the model is to serve in the selection of future management options (Conroy, 1993).

Table I.F-2. Areas (acres and percent of total) of pronghorn winter ranges predicted to be suitable habitats within various probability levels in the PAPA under potential conditions, existing conditions, and different levels of well pad density, including 1 and 2 central production facilities (CPF), within four simulation areas of high exploratory interest on the Pinedale Anticline Crest (Figure I.D-1).

Probability of Suitable Habitat	Potential Habitat Conditions		Existing Habitat Conditions		1 CPF per section (1)		2 CPFs per section (1)		4 well pads per section (2)		8 well pads per section (2)		16 well pads per section (2)	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent
0.91 to 1.00	1,201	3.51	55	0.16	16	0.05	15	0.04	17	0.05	16	0.05	15	0.04
0.81 to 0.90	1,447	4.23	470	1.37	377	1.10	367	1.07	388	1.13	386	1.13	367	1.07
0.71 to 0.80	294	0.86	662	1.93	623	1,82	616	1.80	666	1.94	644	1.88	616	1.80
0.61 to 0.70	155	0.45	321	0.94	218	0.64	224	0.65	235	0.69	232	0.68	224	0.65
0.51 to 0.60	179	0.52	631	1.85	641	1.87	643	1.88	680	1.99	665	1.94	643	1.88
0.01 to 0.50	584	1.70	1,657	4.84	1,1616	4.72	1,626	4.75	1,725	5.04	1,683	4.91	1,626	4.75
0	30,383	88.73	30,447	88.91	30,752	89.81	30,752	89.81	30,532	89.16	30,617	89.41	30,752	89.81

Notes:
1 = Each central production facility (CPF) is assumed to disturb 5 acres over the short-term and each other producing well pad in a section (total of 16 pads) disturbs 3.7 acre over the short-term.
2 = Each producing well pad disturbs 3.7 acres in the short-term. All wells are assumed to be productive in this model. Well pad locations were placed within the four areas on the Pinedale Anticline crest to avoid all areas where BLM would not allow placement on Federal lands and minerals for each of the well-spacing scenarios. Model simulation is only for well pad placement and does not include any effects of roads and pipelines.

Table I.F-3. Areas (acres and percent of total) of mule deer winter ranges predicted to be suitable habitats within various probability levels in the PAPA under potential conditions, existing conditions, and different levels of well pad density, including 1 and 2 central production facilities (CPF), within four simulation areas of high exploratory interest on the Pinedale Anticline Crest (Figure I.D-1).

Probability of Suitable Habitat	Potential Habitat Conditions		Existing Habitat Conditions		1 CPF per section (1)		2 CPFs per section (1)		4 well pads per section (2)		8 well pads per section (2)		16 well pads per section (2)	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent
0.91 to 1.00	770	2.25	42	0.12	42	0.12	42	0.12	1	0.00	1	0.00	1	0.00
0.81 to 0.90	3,524	10.29	352	1.03	303	0.88	298	0.87	218	0.64	215	0.63	212	0.62
0.71 to 0.80	2,304	6.73	999	2.92	627	1.83	511	1.49	457	1.33	451	1.32	432	1.26
0.61 to 0.70	1,354	3.95	305	0.89	233	0.68	210	0.61	208	0.61	208	0.61	199	0.58
0.51 to 0.60	381	1.11	2,274	6.64	2,362	6.90	2,467	7.21	1,976	5.77	1,909	5.57	1,793	5.24
0.01 to 0.50	1,164	3.40	5,407	15.79	5,011	14.63	5,050	14.75	6,317	18.45	6,170	18.02	5,941	17.35
0	24,746	72.27	24,864	72.61	25,665	74.95	25,665	74.95	25,066	73.20	25,289	73.85	25,665	74.95

Notes:
1 = Each central production facility (CPF) is assumed to disturb 5 acres over the short-term and each other producing well pad in a section (total of 16 pads) disturbs 3.7 acres over the short-term.
2 = Each producing well pad disturbs 3.7 acres in the short-term. All wells are assumed to be productive in this model. Well pad locations were placed within the four areas on the Pinedale Anticline crest to avoid all areas where BLM would not allow placement on Federal lands and minerals for each of the well-spacing scenarios. Model simulation is only for well pad placement and does not include any effects of roads and pipelines.

Table I.F-4. Areas (acres and percent of total) of sage grouse nesting areas predicted to be suitable habitats within various probability levels in the PAPA under potential conditions, existing conditions, and different levels of well pad density, including 1 and 2 central production facilities (CPF), within four simulation areas of high exploratory interest on the Pinedale Anticline Crest (Figure I.D-1).

Probability of Suitable Habitat	Potential Habitat Conditions		Existing Habitat Conditions		1 CPF per section (1)		2 CPFs per section (1)		4 well pads per section (2)		8 well pads per section (2)		16 well pads per section (2)	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent	Area	Percent
0.91 to 1.00	15,434	45.07	7,495	21.89	5,946	17.36	5,169	15.10	4,230	12.35	1,372	4.01	495	1.46
0.81 to 0.90	4,874	14.23	5,177	15.12	4,522	13.21	4,400	12.85	4,640	13.55	4,482	13.09	4,112	12.01
0.71 to 0.80	7,509	21.93	4,631	13.52	4,054	11.84	3,835	11.20	3,923	11.46	3,321	9.70	3,149	9.20
0.61 to 0.70	110	0.32	7,206	21.04	6,275	18.32	5,936	17.33	5,105	14.91	3,793	11.08	3,216	9.39
0.51 to 0.60	1,523	4.45	1,079	3.15	1,367	3.99	1,615	4.72	2,101	6.13	2,833	8.27	3,042	8.88
0.01 to 0.50	84	0.24	3,687	10.77	4,568	13.34	5,777	16.87	8,616	25.16	12,161	35.51	12,718	37.14
0	4,709	13.75	4,968	15.51	7,511	21.93	7,511	21.93	5,628	16.44	6,281	18.34	7,511	21.93

Notes:
1 = Each central production facility (CPF) is assumed to disturb 5 acres over the short-term and each other producing well pad in a section (total of 16 pads) disturbs 3.7 acres over the short-term.
2 = Each producing well pad disturbs 3.7 acres in the short-term. All wells are assumed to be productive in this model. Well pad locations were placed within the four areas on the Pinedale Anticline crest to avoid all areas where BLM would not allow placement on Federal lands and minerals for each of the well-spacing scenarios. Model simulation is only for well pad placement and does not include any effects of roads and pipelines.

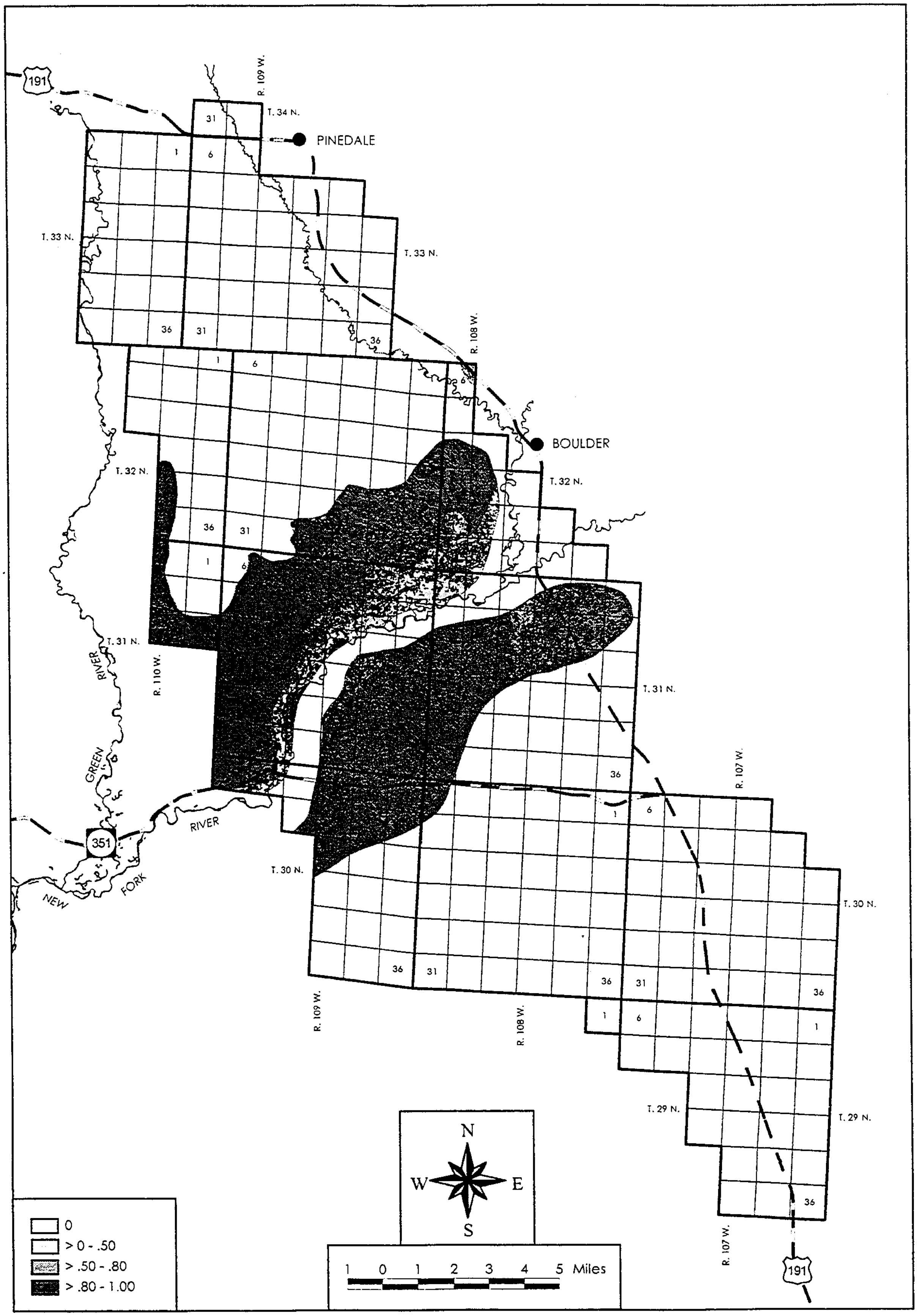

Figure I.F-1. Pronghorn Winter Habitat Within the PAPA With Four Probability Categories for Being Suitable. The PAPA was Evaluated Under Potential Conditions.

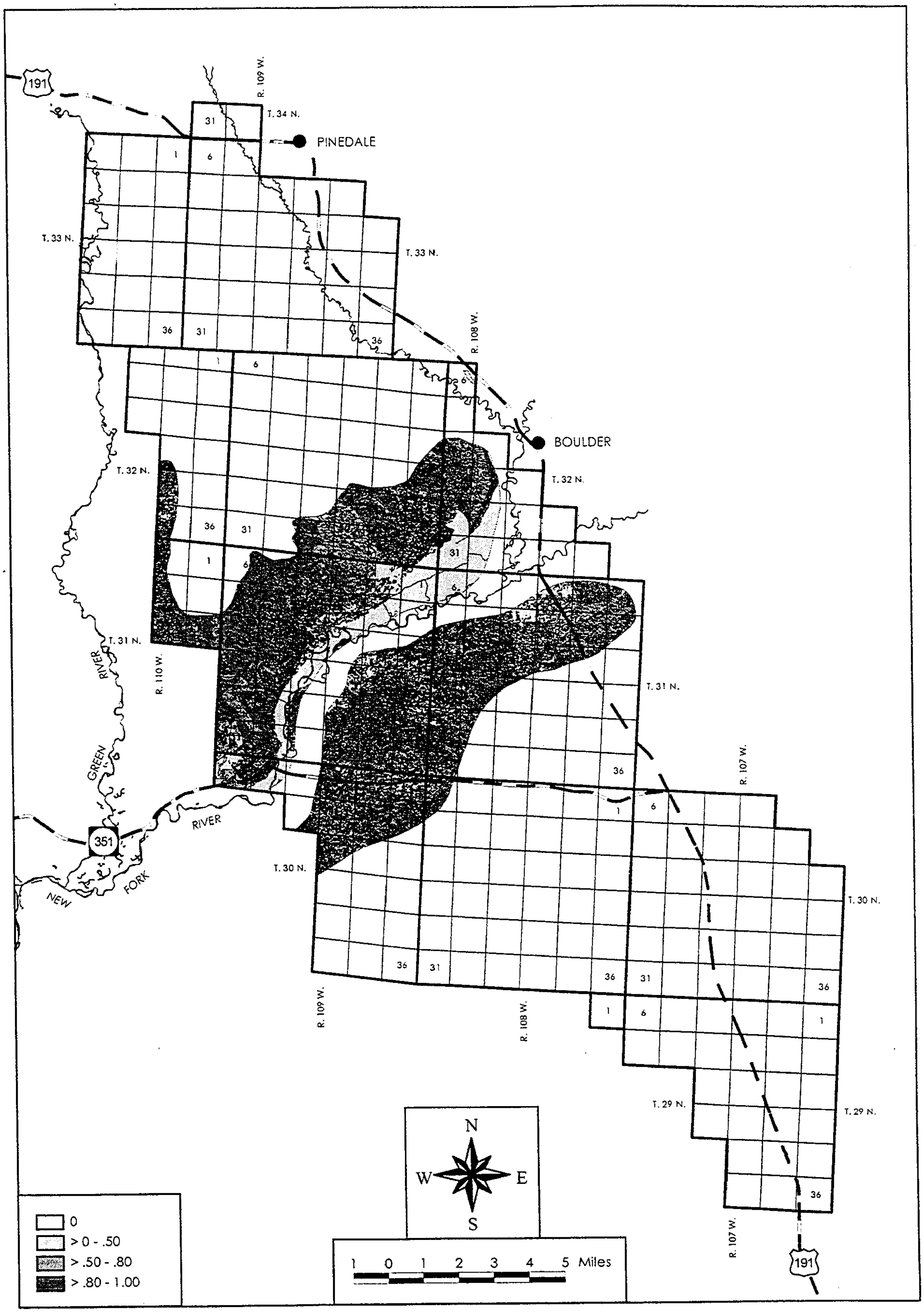

Figure I.F-2. Pronghorn Winter Habitat Within the PAPA With Four Probability Categories for Being Suitable The PAPA was Evaluated Under Existing Conditions.

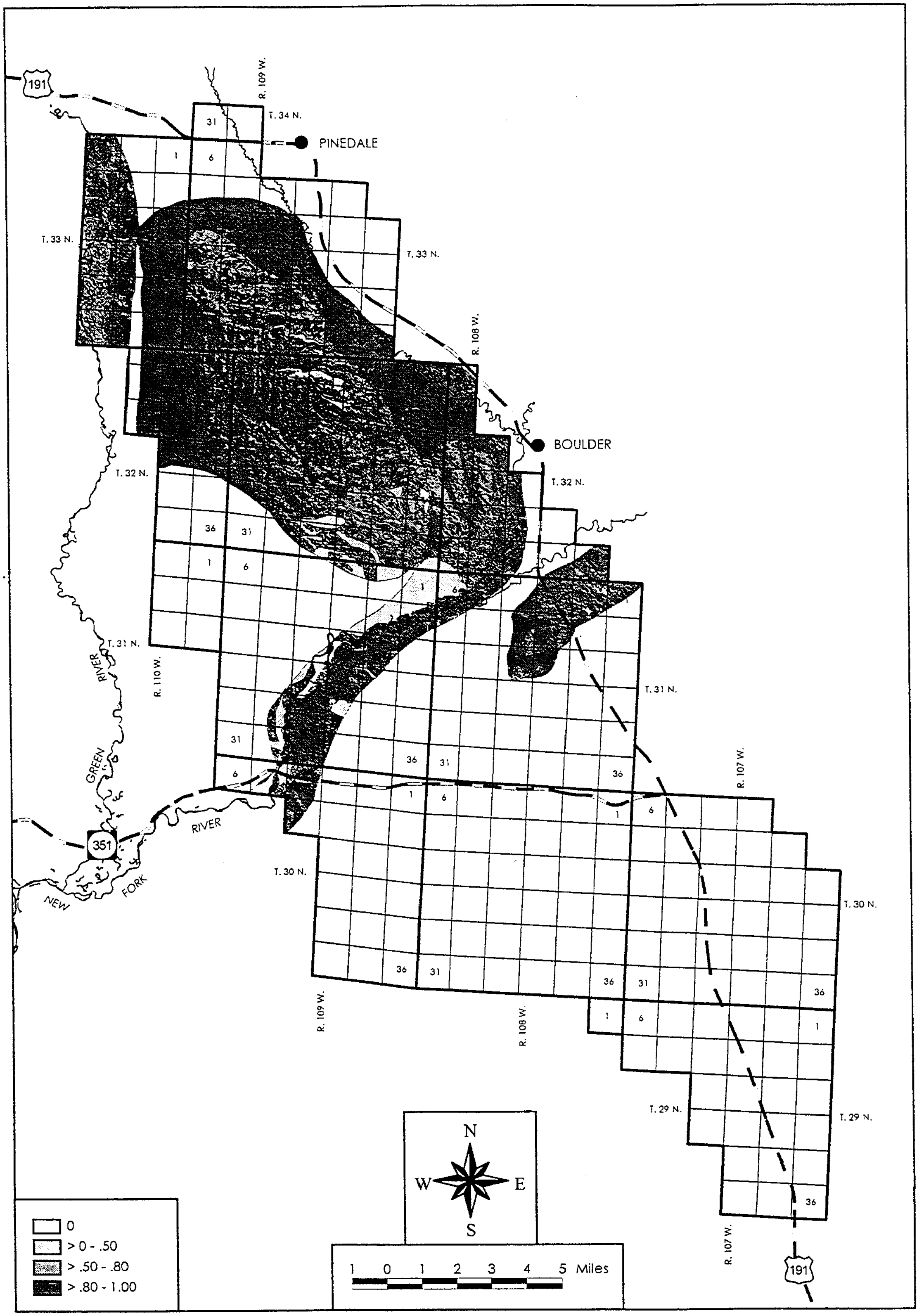

Figure I.F-3. Mule Deer Winter Habitat Within the PAPA With Four Probability Categories for Being Suitable. The PAPA was Evaluated Under Potential Conditions.

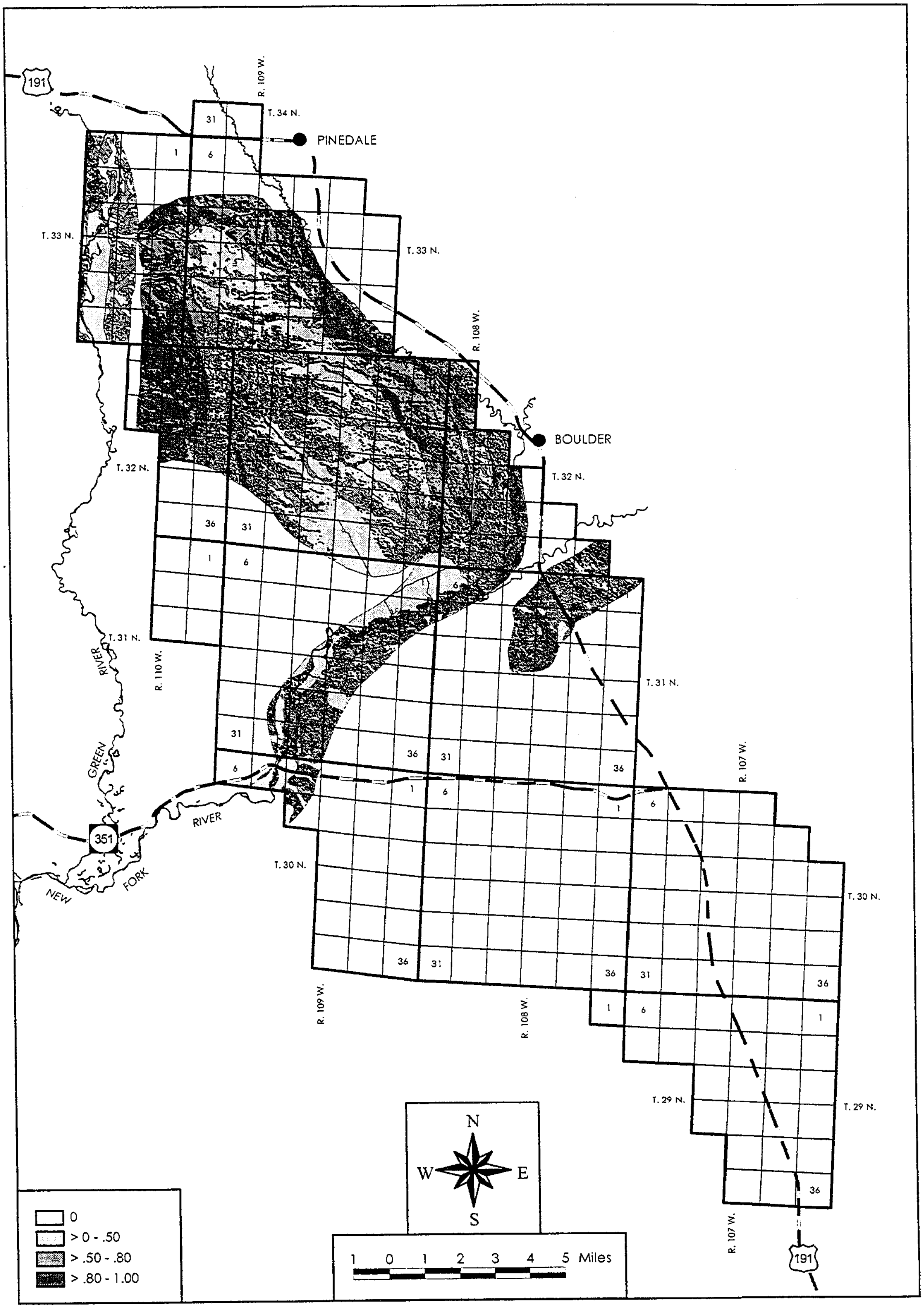

Figure I.F-4. **Mule Deer Winter Habitat Within the PAPA With Four Probability Categories for Being Suitable The PAPA was Evaluated Under Existing Conditions.**

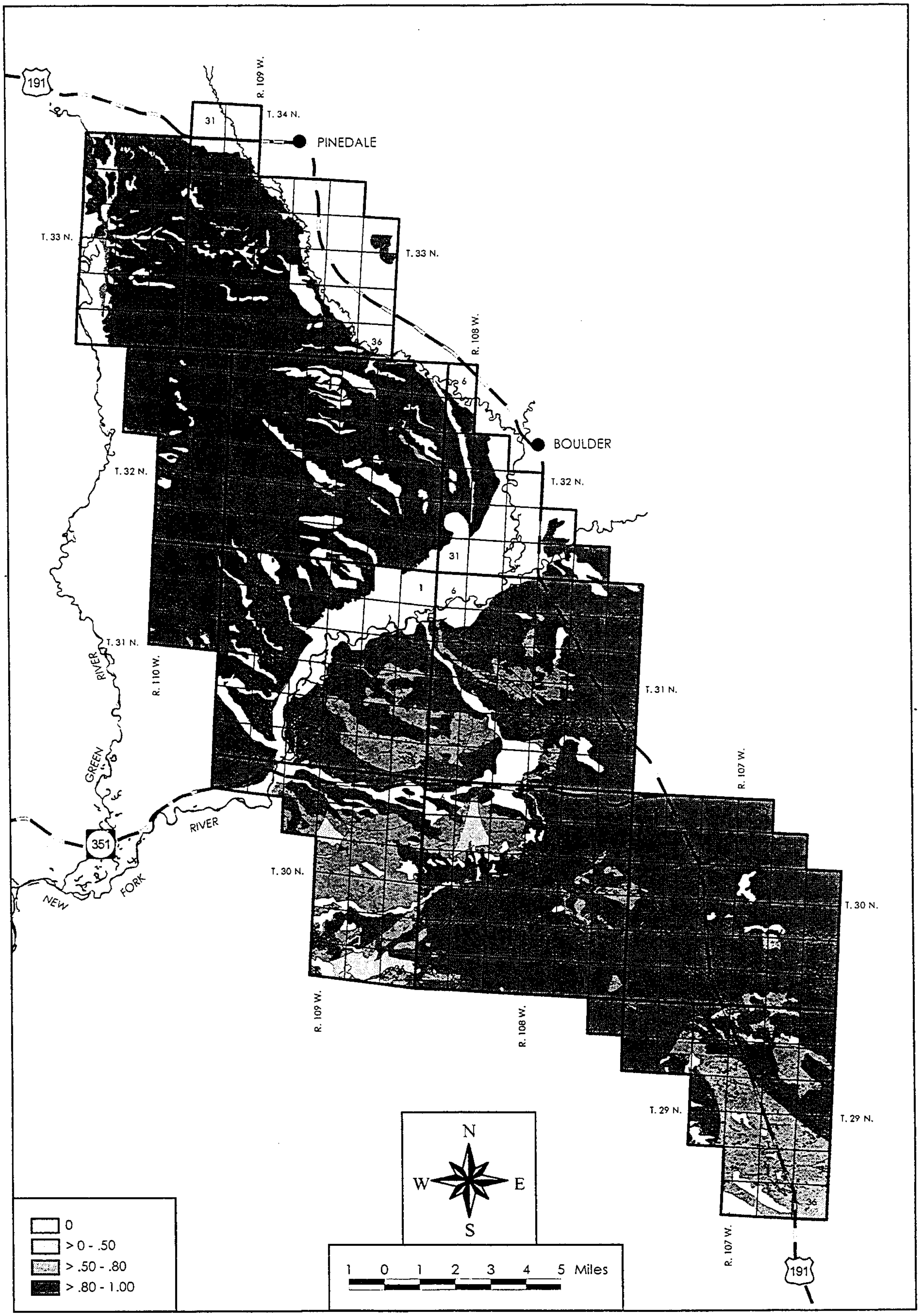

Figure I.F-5. Sage Grouse Nesting Habitat Within the PAPA With Four Probability Categories for Being Suitable. The PAPA was Evaluated Under Potential Conditions.

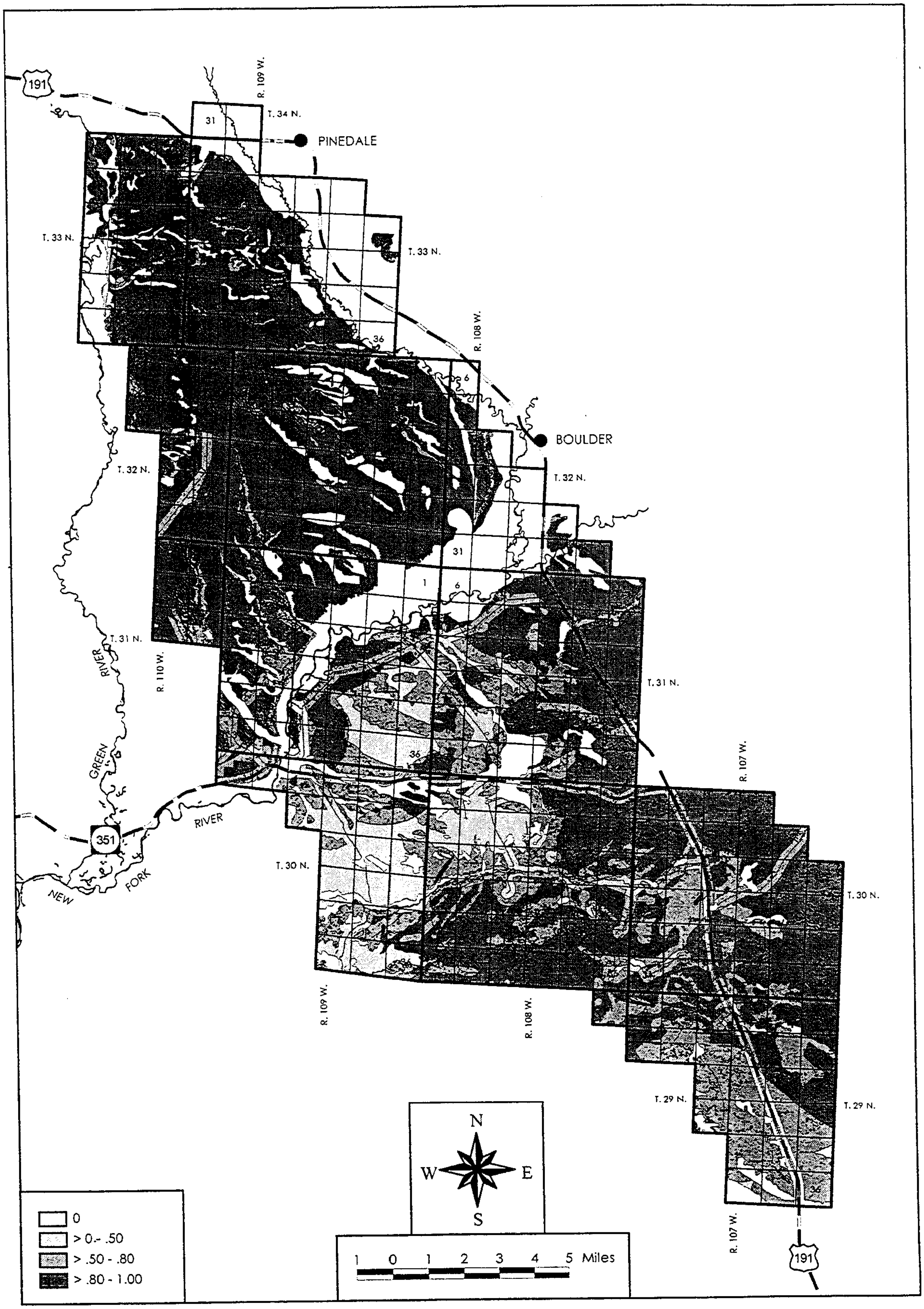

Figure I.F-6. Sage Grouse Nesting Habitat Within the PAPA With Four Probability Categories for Being Suitable The PAPA was Evaluated Under Existing Conditions.